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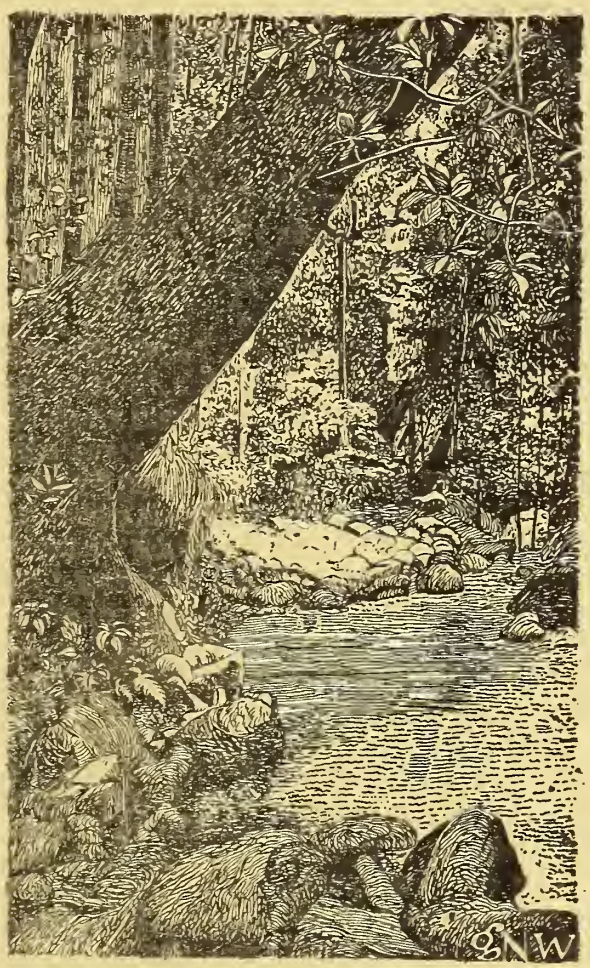
The Caribbean Forester



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TROPICAL FOREST EXPERIMENT STATION
RIO PIEDRAS, PUERTO RICO

VOLUME 17, NOS. 1 AND 2 JANUARY - JUNE, 1956

Caribbean Forester

El "Caribbean Forester", revista que el Servicio Forestal del Departamento de Agricultura de los Estados Unidos comenzó a publicarse en julio de 1938 se distribuye semestralmente sin costo alguno y está dedicada a encauzar la mejor ordenación de los recursos forestales de la región del Caribe. Su propósito es estrechar las relaciones que existen entre los científicos interesados en la Ciencia Forestal y ciencias afines encarándoles con los problemas confrontados, las políticas forestales vigentes y el trabajo que se viene haciendo para lograr ese objetivo técnico

Se solicita aportaciones de no más de 20 páginas mecanografiadas. Deben ser sometidas en el lenguaje vernáculo del autor, con el título o posición que este ocupa. Es imprescindible incluir un resumen conciso del estudio efectuado. Los artículos deben ser dirigidos al Líder, Centro de Investigaciones Forestales Tropicales, Río Piedras, Puerto Rico.

Las opiniones expresadas por los autores de los artículos que aparecen en esta revista no coinciden necesariamente con las del Servicio Forestal. Se permite la reproducción de los artículos siempre que se indique su procedencia.

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The "Caribbean Forester", published since July 1938 by the Forest Service, U. S. Department of Agriculture, is a free semiannual journal devoted to the encouragement of improved management of the forest resources of the Caribbean region by keeping students of forestry and allied sciences in touch with the specific problems faced, the policies in effect, and the work being done toward this end throughout the region.

Contributions of not more than 20 typewritten pages in length are solicited. They should be submitted in the author's native tongue, and should include the author's title or position and a short summary. Papers should be sent to the Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

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Le "Caribbean Forester", qui a été publié depuis Juliet 1938 par le Service Forestier du Département de l'Agriculture des Etats-Unis, est une revue semestriele gratuite, dediée a encourager l'aménagement rationnel des forêts de la region caraibe. Son but est d'entretenir des relations scientifiques entre ceux qui s'interéssent aux Sciences Forestières, ses problèmès et ses méthodes les plus récentes, ainsi qu'aux travaux effectués pour réaliser cet objectif d'amelioration technique.

On accept voluntiers des contribution ne dépassant pas 20 pages dactilographiées. Elles doivent ètre écrites dans la langue maternelle de l'auteur qui voudra bien préciser son titre ou sa position professionnelle et en les accompagnant d'un résumé de l'étude. Les articles doivent ètre addressés au Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

La revue laisse aux auteurs la responsibilité de leurs articles. La reproduction est permise si l'on présice l'origine.

*The printing of this publication has been approved by the Director of the Bureau of the Budget (August 26, 1953)

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Sixteenth Annual Report

Tropical Forest Research Center
Puerto Rico

The year 1955 was marked by a substantial expansion of the activities of the Research Center. A new project of watershed management was set up, the Caribbean National Forest was taken over for research purposes, a program of cooperative forest management with the local governments and private landowners in both Puerto Rico and the Virgin Islands was undertaken, and a full-time program of training for foreign forestry students was inaugurated.

Forest management research, on the other hand, suffered from a vacancy in the Project Leader position for 6 months of the year. Because of this circumstance new experiments were limited almost entirely to four in the Virgin Islands, described in more detail later in this report. These experiments, carried out cooperatively with the Virgin Islands Corporation and the Virgin Islands Experiment Station, involved six trips to the area during the year. The reexamination schedule for the 356 tests in progress in Puerto Rico and the Virgin Islands at the beginning of the year was revised to reduce this job to the bare minimum which would assure adequate information as to the results. Of these tests 84 were terminated, and 19, including 6 in the Virgin Islands, were started during the year.

Much of the time of the available Forest Management personnel has been dedicated to compilation of information for two large publication, a bulletin on planting, and a descriptive book on Trees of Puerto Rico for which the senior author is Dr. Elbert L. Little, Jr. of the Division of Forest Management Research of the office of the Chief in Washington. At the end of the year the checking of the tree descriptions and the translation of the first review draft into Spanish by the Forest Management staff was nearly completed. The data for the planting bulletin have all been brought together.

The administration of the Caribbean National Forest, and area of some 33,000 acres, was assigned the Center for research purposes in July. By the end of the year a plan was prepared for the future use of the Luquillo Division of this forest. Included are long-range experiments in silviculture and a large-scale pilot-demonstration forest management project which will apply best known practices of silviculture, timber harvesting, and utilization.

A watershed management research project was begun in the second half of the year with the assignment of three professional men. The project leader, available only part time because of primary responsibilities for the foreign training program, has begun work on a problem analysis as a step preliminary to long-range research in this field. The other two men in this Division are specialits on a one-year assignment from the Vicksburg Infiltration Project of the U. S. Army Engineers. This Project is concerned with the prediction of soil moisture and trafficability. The research has consisted of taking daily readings on rainfall, soil moisture and temperature, and soil strength at 7 sites and similar data on a monthly basis for an additional 23 sites.

The cooperative forestry program taken over in July provides a new opportunity for the Center to reach the practitioner with the results of research. In Puerto Rico this cooperation has been with both the Commonwealth government and with forest landowners. With the Commonwealth it has included assistance in the orientation of the joint Federal-State program of propagation and distribution of forest tree nursery stock to farmers and related technical advice on nursery practices. In addition, a joint field study was made by the forestry staffs of the two governments of problems related to the administration and management of six of the

Commonwealth forests. Plans have also been completed with the Department of Public Works for the establishment of 4 kilometers of timber tree plantings along key roads.

With farmers the cooperative forestry program has concentrated on the location of key farms for the establishment of demonstration woodlots of ½ acre or more. Twelve farms of this type have been found and plans made for the farmer to complete the plantings during the next wet season. This program is an attempt to spearhead a new technique of giving much more preliminary attention to farm plantings, technical advice at the time of planting, and subsequent follow up. If results are as successful as anticipated it is hoped that the Division of Forests and the Extension Service will adopt this practice in the future.

In the Virgin Islands a full time forester was appointed by the Center during the year, financed by the Virgin Islands Corporation. His work is primarily the encouragement of forest inmprovement on private lands in those islands by underplanting native forests with mahogany stands, and by harvesting and utilizing mature trees. Some 19,000 mahogany trees were planted cooperatively by farmers as a result of this program during the year. The 130-acre Thomas Estate Demonstration Forest, an area of excellent young mahogany stands, was given an improvement cutting. A small circular sawmill was set up and readied for cutting local timber for farm use, industrial development, and research purposes. Material assistance was offered in the research work in progress in the Virgin Islands, including seed collections, the setting up of plots in the field, planting, and subsequent measurements.

Recognition of the increasing importance of forestry training at the Center came with the assignment during the year of a forester nearly full time to this activity, financed by the International Cooperation Administration. A 3-month training course was held in the spring of the year, with 26 foreign students present. The Food and Agriculture Organization of the United Nations assisted in this course in various ways, including the sending of two instructors. A second, 8-week session was held in the autumn for four students from the British Caribbean islands.

Forest utilization research was concerned chiefly with the study of machining properties, air-seasoning characteristics, and certain related physical properties of 60 native timbers. The remodeling of the wood testing laboratory buildings was completed and the required machines and equipment were installed. Nearly all of the lumber required had been cut and was drying or under test at the end of the year. The Project Leader made a trip to the Forest Products Laboratory at Madison, Wisconsin for consultation in regard to this research, and also to attend the Annual Program Planning Conference. Mr. E. M. Davis of the Laboratory spent 10 days in Puerto Rico to assist with techniques for the machining tests.

The major international activity of the Center, in addition to the training, was participation in the Fifth Session of the Latin American Forestry Commission of FAO, at Caracas, Venezuela. The Center Leader attended this conference as an advisor to the U. S. Delegation and served on the subcommission concerned with the proposed Latin American Forest Research and Training Institute at Merida, Venezuela.

The Center has received more cooperation in its activities than ever before. This is particularly true in the field of training, where virtually all agricultural agencies, both Federal and Commonwealth, were of assistance. In addition to other types of cooperation already mentioned, the Center is indebted to the Division of Forests, Fisheries and Wildlife for continued assistance in the conduct of field experiments on lands under their administration. This cooperation has been responsible for many of the findings reported here.

FOREST MANAGEMENT RESEARCH

The more important results of forest management research in progress during 1955 are described briefly here. Some of these will soon be presented more completely in published form. Others are only partial and represent progress reports on long-range studies.

The results of research are presented for each of the major forest problem areas under study. These problem areas, described in detail in last year's report, cover nearly one-third of Puerto Rico. They are areas where forest is the only or the most promising crop.

Humid Tuffaceous Loams

One of the largest potential forest areas of Puerto Rico is characterized by shallow loam soils derived from tuffaceous rock. About 170,000 acres are included. Slopes are steep, generally exceeding 60 percent. Elevations range from 300 to 2,500 feet. Rainfall ranges from 70 to 120 inches annually.

The chief problem in this area is reforestation. Regeneration research is in progress with a number of native and exotic tree species. Almost nothing has been known about the potential productivity of the scattered native forests of this region.

Woodlot Management

Most of the humid tuffaceous loam area is in small private holdings. Thus it is imperative that an effort be made to show forestry profitable for the farmer. With this in mind a 10-acre mixed secondary forest in the St. Just Experimental Area was placed under intensive management in 1942. Areas were subjected to annual improvement cuttings favoring the trees of best form and species. In one area the objective has been to produce sawtimber and in another to produce fence posts. Quarter-acre sample plot records indicate stand developments and the yields to be expected.

In the stand where sawtimber is the objective the basal area was 455 square feet and the volume, 878 cubic feet per acre (in trees of 2 inches d.b.h. or more) after cutting in 1954. The annual increment per acre during the two previous years was 218 cubic feet. The stand is still too young to yield sawtimber but produced 134 fence posts annually the last 2 years. These, on the stump, were worth $5.36 or manufactured, $16.08. Seventy-nine percent of the trees remaining are of sawtimber species and form.

In the stand where fence posts are the objective the basal area was 40 square feet and the volume, 717 cubic feet per acre after cutting in 1954. The annual increment per acre during the two previous years was 165 cubic feet. Cuttings during the past 2 years produced 184 fence posts annually. These, on the stump, were worth $7.36 or manufactured, $22.08. All of the trees remaining in this stand are of species and form suited for posts.

The yields in the fence post stand is probably indicative of what can be expected under management. In the sawtimber stand the value of the yield will rise continuously as tree size increases.

Deep Lateritic Clays

Some 190,000 acres of steep slopes in the interior of Puerto Rico constitute a second important potential forest area. Elevations range from 500 to 4,000 feet with rainfall from 80 to 200 inches annually.

The chief problem in this area is reforestation, but there are also extensive areas of degraded secondary forests and abandoned coffee plantations which need silvicultural improvement to increase their productivity. Research is in progress in reforestation with a large number of species on different sites. The betterment of existing forests both by partial cuttings and by underplanting is also being investigated.

Hurricane Damage

Hurricane Connie on August 6, 1955 passed about 135 miles north of an 18-year-old plantation of broadleaf mahogany *(Swietenia macrophylla* King) in the Luquillo Forest. Winds reported to range in gusts up to 60

miles per hour caused severe damage in about 50 acres of plantations. This was the first opportunity in 24 years to study the effects of a hurricane upon forest plantations in Puerto Rico.

The plantation in this area is located on the slopes of a deep North-South valley. The elevation is about 1,200 feet and the rainfall averages about 140 inches annually. The soil is a deep red clay with many boulder outcrops. The plantation was established in deforested areas following shifting cultivation. Within the plantation are many areas of natural forest, and some native trees are in places mixed with the mahogany. In the first few years of the plantation it was noted that the trees were not windfirm and tended to blow over easily. However, subsequently the remaining trees formed buttresses, and windthrow ceased. By 1955 the average diameter of dominant and codominant trees had reached 10 inches.

The damage occurred only on west slopes, yet the trees were thrown northward. More trees were affected in the valleys than on the ridges. Mahogany was far more susceptible to windthrow than any associated native species, even including yagrumo hembra *(Cecropia peltata L.)*. In the pure plantation as many as 80 percent of the mahoganies were windthrown over areas as large as an acre. Most of the trees affected were uprooted rather than broken off. There was little apparent relationship between tree size or exposure and damages. In some areas a few fine large specimens, with diameters up to 14 inches survived undamaged with other down all around them. Other mahoganies, protected beneath a native overstory, were blown down although the overstory remained undamaged. The only evidence of any pattern was a tendency for the completely devastated areas to be arranged in strips of about 100 feet in width, perpendicular to the wind direction. Between these strips there was relatively little damage.

A most striking characteristic of the uprooted trees was the limited spread of their root system. Examination showed the average diameter of the root system to be only 1 foot for every inch of stem diameter at breast height. This limitation, possibly caused by excessive soil moisture, appears to be a basic weakness of the species in this environment.

The hurricane winds did not reach mahogany plantations on other sites in Puerto Rico. It is hoped that they will not prove to be as susceptible as in the Luquillo Mountains. Planting of mahogany, heretofore the most promising species for moist deep clays, has been at least temporarily suspended.

The effect of the hurricane upon the native forest, even in the immediate vicinity of the damage mahogany, was negligible. No sawtimber-sized trees of native species were damaged. Breakage in the native forests was almost entirely confined to the soft-wooded rapid growers which spring up in openings but were already disappearing with the redevelopment of a mixed forest beneath them.

Natural Regeneration

The first extensive natural regeneration of broadleaf mahogany *(Swietenia macrophylla* King) was discovered in March 1955 under a 27-year-old pure plantation in the Luquillo Mountains. This plantation is located at an elevation of about 800 feet and receives a rainfall of about 90 inches annually.

The plantation was undamaged until its 25th year, at which time it was lightly thinned to 105 square feet of basal area. The average diameter of the remaining dominant and codominant trees was 11 inches at that time.

In 1953, the first year subsequent to the thinning, a crop of fruits was noticed on the trees for the first time. The first seedling counts in 1955 were made in seven circular plots of 20 feet in diameter. Counts ranged from 2,200 to 14,300 seedlings per acre, many of which were obviously in their second year. Subsequent counts in December showed virtually no mortality. There now appears to be little doubt that this species, once established, should be easy to regenerate.

Artificial Regeneration

A major obstacle to reforestation by private landowners is the cost of weeding recently planted trees. An ingenious technique used under some conditions outside of Puerto Rico is the interplanting of food crops between the rows of trees. The crop yields harvested before the trees dominate pay the costs of cultivation and plantation establishment. The rapid growth of eucalyptus in this region and the light shade produced by plantations of this species in Puerto Rico suggested intercultivation as a substitute for weeding. A test was started in 1953 in the Toro Negro forest at 2,800 feet elevation with a rainfall of 120 inches annually.

The test area covered an acre. Trees of *Eucalyptus robusta* Smith were planted at an 8 x 12-foot spacing, and interplanted with bananas. At the end of 18 months both the trees and the bananas are very thrifty. The trees average about 10 feet tall with a maximum of 15 feet. This is about double the growth nearby without intercultivation. The bananas have not yet fruited but a good crop is anticipated. Observations will continue to determine if and when the bananas should be removed. Because they are shade tolerant, it may prove possible to produce both crops throughout the rotation.

Plantation Growth

One of the more promising exotic trees for planting in this region is the blue mahoe *(Hibiscus elatus* Sw.), a native of Jamaica and Cuba. Plantings in humid forests were attacked at an early age by the West Indian peach scale and considered beyond redemption. However, the insect attacks, apparently influenced by weather conditions, have subsided to a point where a small planting in the Toro Negro Forest suggests more extensive trials.

The mahoe at Toro Negro is growing at an elevation of about 2,600 feet with a rainfall of about 110 inches annually. It was planted in a protected cove on land formerly cultivated and abandoned. Trees not damaged by insect attack are of excellent form and, after 7 years average 5.5 inches d.b.h. and 65 feet in height. The largest trees are 9 inches in diameter and 75 feet tall. This growth is comparable to eucalyptus, yet the wood of this species is of quality suitable for furniture.

Granitic Loams

The granitic loam soils of the central and eastern mountains are one of the highest erosion hazards in the island. Some 59,000 acres of these soils, on slopes in excess of 60 percent, are considered suitable only for forest.

The major forest problem in this region is reforestation, although a substantial area of secondary forest needs improvement. Research on both techniques is in progress.

Plantation Growth

One of the earliest forest plantations in Puerto Rico was established in the Luquillo Forest at an elevation of 1,200 feet in 1931. The annual rainfall is about 140 inches. The species is broadleaf mahogany *(Swietenia macrophylla* King). Now after 24 years the dominant and codominant trees range from 12 to 21 inches, d.b.h.

Forty trees in this plantation have been under study for the past 3 years to determine current diameter growth. The annual growth of 18 dominant and codominant trees has been 0.84 inch, as rapid as for any other species on this site, including eucalyptus. Even the trees in the intermediate crown class grow 0.59 inch. These trees are of excellent form and well buttressed. They have not yet experienced a hurricane but nevertheless this is the most promising timber species for this soil type.

Mexican cypress *(Cuppressus lusitanica* Mill) previously reported as of rapid growth on deep clay soils is also developing well on granitic loam in the southern portion of the Luquillo Forest. The site is located at about 2,000 feet elevation and receives about 140 inches of rainfall annually.

A test planting was established in 1948 and by 1955 average 4 to 6 inches d.b.h. and 20 to 25 feet in height. A few of the trees have tipped over as is apparently characteristic of this species at elevations as low as this, but the stand in general shows no sign of this problem. Further trials of this species on this soil, particularly in the Central Mountains, are warranted.

The Laterite Soils

Near the western end of the Central Cordillera is an area of about 22,000 acres of laterite soil which, because of low fertility, is unsuited to other than forest crops. The soil ranges from shallow to deep, elevations from 800 to 2,500 feet, and rainfall from 50 to 100 inches annually.

The major problems are reforestation of bare lands and the betterment of unproductive secondary woodlands. Research is in progress in reforestation and subsequent plantation management.

Artificial Regeneration

The absence of a high quality native species generally adapted to the more humid deeper soils of this type at higher elevations led to introductions in 1953, previously reported, of a variety of pines. The species tested included *Pinus canariensis* C. Sm., *P. halepensis* Bieb., *P. patula* Sch. & Cham., *P. taeda* L., *P. occidentalis* Swartz, *P. radiata* D. Don, *P. caribaea* More, *P. pinaster* Aiton, *P. pinea* L., and *P. densiflora* Sieb. & Zucc.

The plantings were made in the Maricao Forest at an elevation of about 2,000 feet, and with about 100 inches of rainfall annually. During the first year the trees became chlorotic in appearance and ceased growth. Ammonium superphosphate was applied as a soil amendment but produced no visible reaction in the seedlings. Finally, in 1955, mycorrhiza from stands of *P. taeda* L. and *P. echinata* Mill. in the southern United States were added to the soil around the roots of the trees. No conclusive results are yet available.

Humid Limestone

The humid limestone region covers about 150,000 acres between the Cordillera and the northern coastal plain. It is chiefly of steep hills with soil which is shallow and of low productivity for cultivated crops. Elevations range from sea level to about 1,000 feet and rainfall from 60 to 80 inches annually.

The chief forest problem in this region is the improvement of existing forests. Research is in progress on stand betterment and particularly the introduction of superior tree species into the stands.

Woodlot Management

A typical forested area in this region was selected in 1950 in the Cambalache Experimental Forest for experimental management as a farm woodlot. It has been subjected to annual improvement cuttings. There are no sawtimber species present so the objective of management has been the production of fence posts.

The first measurements made in this stand showed that woodlot improvement purely by partial cuttings would be slow and would yield little early reward. The average tree diameter was 2 inches, with the largest to 5 inches. Tree form was poor and vines covered much of the stand. Even after 5 years almost no fence posts have been produced. However, the stand itself has been improved materially. The basal area in good post species increased from 22 to 31 square feet per acre, and now constitutes 79 percent of the stand. Seventy-five percent of the saplings are of these better species.

This stand has been gradually improved silviculturally, but the practice has so little to recommend it from the standpoint of immediate economic returns that the only promising approach appears to be unterplanting with superior species.

Underplanting

Broadleaf mahogany *(Swietenia macrophylla* King) is still the most promising tree

for introduction into the natural forests of this region. An underplanting was made in the Cambalache Experimental Forest in 1945. Elevation is about 100 feet and rainfall 60 inches annualy. After 10 years the dominant and codominant trees had attained an average d.b.h. of 4 inches and an average height of 30 feet. The best growth in this plantation has taken place within 50 feet of the bottoms of the slopes. The trees required frequent opening in the first 5 years to assure them of light from above.

Blue mahoe *(Hibiscus elatus* Sw.) referred to elsewhere in this report, is also well adapted to the lower slopes in the Cambalache Forest. However, it is less tolerant than mahogany and requires heavy release from overhead shade at an early age. At age 10 years the dominant and codominant trees average 5 inches in d.b.h. and 50 feet in height. Form is excellent, and this is the only location in the island where the trees have been entirely free from attack by the West Indian peach scale.

Tidal Swamps

About 16,000 acres of tidal swamps along the coast of the island cannot be drained economically. This area is covered with young mangrove which because of its accessibility and rapidity of growth is potentially a highly productive forest.

The most important problem in this forest is the determination of effective techniques for promptly regenerating the forest with the more desirable species. A second problem is the need for thinning practices. Research on both of these problems has been in progress for several years.

Natural Regeneration

A thinning made in a 22-year-old pure stand of white mangrove *(Laguncularia racemosa* (L). Gaertn.) produced an almost immediate increase in increment but did not bring on natural regeneration.

Extensive areas of white mangrove within the Aguirre Forest are mature for poles, the highest use of this species. Whereas experience had shown that the regeneration of such a forest would take place after clear cutting, such regeneration is normally so dense that the development of the new stand is believed to suffer. Accordingly, when in 1952 a thinning was made experimentally in two ¼-acre plots the objective was partially to determine whether a more satisfactory new stand would develop beneath it.

The diameter of the dominant and codominant trees ranged from 5 to 12 inches. The average basal area in trees of 2 inches or more, d.b.h. was 134 square feet per acre, and the standing volume was 2,960 cubic feet per acre. Mean annual increment had been 128 cubic feet per acre per year. The thinning reduced the basal area to 70 square feet per acre. Increment for the first 3 years following thinning was 125 cubic feet per acre per year, as compared with 29 cubic feet in the unthinned plots.

The acceleration of increment resulting from this thinning is pronounced but of secondary importance, in that most of the stems are already mature. The thinning was unsatisfactory as a preparatory cutting for regeneration. The stand, even-aged without young trees beneath it at the time of thinning, is now more open but it is still without a new crop on the ground. This is true even in one plot where only 63 square feet of basal area per acre were left. Beneath the larger canopy openings there are ferns but except for a few scattered saplings of red mangrove *(Rhizophora mangle* L.) and black mangrove *(Avicennia nitida* Jacq.) no new trees have appeared.

The most important conclusion from this study is in regard to the intolerance of white mangrove. In upland forests a satisfactory stand of reproduction of at least some species would develop under the conditions created by the thinning. White mangrove apparently will not. Heavier thinning would apparently be unwise because of the constant danger of windthrow on this site. A windstorm in 1949,

even before the thinning, eliminated 120 trees per acre, including many dominants. Apparently regeneration can best be brought about by clearcutting.

A practical technique for obtaining prompt regeneration of clearcut mangrove areas was developed in the Aguirre Forest as a result of a study which began in 1951. Since that time a strip 1 chain wide and perpendicular to the prevailing wind direction has been cut each second year. Each new strip is adjacent to the last strip cut, and on the windward side. This has produced complete stands of white mangrove saplings in 24 months. After 4 years the trees are 2 to 4 inches d.b.h. and to 25 feet in height.

Past observation in the natural regeneration of white mangrove following clearcutting led to the conclusion that it is mostly coppice. This has been a source of some concern since sprouts, although they grow rapid at first, are generally of poor form and necessitate early thinnings.

A comparative study of 80 sprouts and seddlings in the strip cutover in 1951 was undertaken in 1954.. At this time it was still possible to distinguish the sprouts from the seedlings. The sprouts tended to be larger (1.5 inches d.b.h. average vs. 1.0 inch for seedlings) but the latter were straighter, and would generally be easily identified by characteristic swellings at the base. A remeasurement at the end of the first year, while not entirely conclusive, showed results so striking as to appear worthy of reporting. The average diameter growth of 55 sprouts was 0.27 inch, whereas that for 19 comparable seedlings will hold their own in the canopy and possibly continue to outstrip the sprouts in development. If this finding proves generally applicable it will eliminate the major objection to clearcutting of white mangrove and will greatly simplify management.

The Virgin Islands

The American Virgin Islands, with a forest land area of approximately 45,000 acres, have undertaken a forestry program in recent years, sponsored by the Virgin Islands Corporation. The chief problems are the improvement of extensive brushlands and the reforestation of arroyos and stream courses.

Forest research has been in progress in the Virgin Islands since 1953, in cooperation with the Virgin Islands Corporation and the Virgin Islands Agricultural Experiment Station of the U. S. Department of Agriculture. Studies have concentrated chiefly upon underplanting of mahogany (*Swietenia mahagoni* Jacq and *S. macrophylla* King).

Seed Studies

Poor viability of the seed of both species of mahogany has during the past 3 years greatly limited the progress of tree propagation, and investigations of broadcasting and direct sowings in the field. Such losses in past years were attributed to lack of refrigeration during storage, in accordance with experience in Puerto Rico. However, germination tests made in 1955 showed initial viability to be extremely erratic and generally low. The highest germination percent obtained for any sample of broadleaf mahogany *(S. macrophylla)* was 62 percent. For West Indian mahogany it was 19 percent. These figures are lower than those obtained from Puerto Rico.

Attention is now concentrated upon improved seed collection and handling techniques. Collection of seed, heretofore done chiefly by school children, in part for publicity purposes, will in the future all be done by trained crews. Other possible past sources of viability loss, failure to clean the seed promptly, and high-temperature drying under direct sunlight, will be eliminated. Refrigerated storage has already been introduced.

Teak *(Tectona grandis* L.) is being tested for reforestation of arroyos in St. Croix. Germination of the seed proved so slow that production of nursery stock has been costly. As a result two presowing treatments in use in the Far East were tested.

A replicated experiment was set up to compare germination of seeds untreated with those alternately soaked and dried in the sun each for 2 days over a total period of 10 days and with those soaked continuously and exposed to direct sunlight each day. It was assumed that in the last treatment the seeds would begin to germinate in the water, at which time they would be individually sown.

After 125 days the germination of the control was 9.5 percent, and that of the alternating treatment 25 percent. None of the seeds in the third treatment had germinated, so they were all then sown. These, after another four months had germinated 31 percent. These two pretreatment produced significantly higher germination, and the alternate soaking and drying treatment is recommended. However, none of the treatments produced the desired result, prompt and complete germination. Storage for 1 year prior to sowing is now being tested.

Field Sowing

An extensive test of broadcasting and direct sowing of both mahoganies on three sites was laid out in St. Croix during the year. The experiment was only partially successful because of a lack of good seed. With germination negligible in the February and May sowings it was assumed that the remaining seed would lose all viability by the time for the final sowing in September. Thus at that time a new seed lot which had been cold stored was used. These seeds, although not much better, gave the only positive results from this study.

Results to the end of the year are not final for the September sowings, since the dry season lies immediately ahead. To this time, however, there is an average of one or more seedlings per spot (10 percent germination or more) in all treatments. Broadleaf mahogany germination is as high on the coastal plain as in the interior. Broadcasting on the *coastal* plain was comparatively a failure, with less than 1 percent survival. In the more humid mountain, however, broadleaf mahogany showed a germination of 5 percent. It was striking that all of the broadcasted seeds which germinated at this location had fallen in planting holes dug by mistake in these plots and left uncovered. Such seeds gave better results than those spot sown and covered in adjacent plots. This method of showing will be fully tested in the future.

Underplanting

Underplanting was tested for comparison with broadcasting and direct seeding, to test bare rooted West Indian mahogany stock, and also to determine the adaptability of broadleaf mahogany to the coastal plain. The planting was done in September, so only the immediate losses can be reported at this time.

The most outstanding finding so far evident from this study is that sturdy stock of West Indian mahogany can apparently withstand bare rooted planting if special care is taken. In two locations on the coastal plain 3-month survival has been as follows:

Treatment	Survival Percentage
1. Potted (check)	98
2. Bare-rooted	
a. Cut back to 2 inch height	86
b. Root pruned, 60 days before lifting	82
c. Defoliated when lifted	65
d. Transplanted 90 days before lifting	83

It is not yet possible to make final comparisons among the treatments. However, if the trees survive the approaching drought it is certain that some of them will prove more practical than the use of pots.

The broadleaf mahogany tested on the coastal plain was all planted with pots. Survival to date has averaged 92 percent. If these trees survive the dry season on the coast the use of more productive species will be preferable to West Indian mahogany.

FOREST UTILIZATION RESEARCH

About half of the study of machining properties, air-seasoning characteristic and certain

related physical properties of 60 native timbers was completed. Some 350 sample logs of the 60 principal sawlog-size hardwoods of the rain forest were cut during the year. These were cut from more tran 300 sample trees and produced about 20,000 board feet of lumber required for the study.

Logs were cut by Forest Service crews, skidded by ox teams to the roads, hand loaded onto light trucks and hauled to the one available sawmill. Work was complicated by the steep terrain and the insect problem. Logs had to be treated immediately after felling to prevent attack by pin-hole borers.

Sample logs of 37 of the species were sawn into boards for testing. Air seasoning, specific gravity and shrinkage determination have been completed for 15 woods and are nearing completion for the other 22 woods. Machining tests and other related tests are nearly completed for 15 woods. All tests on the 50 species are scheduled for completion by June 30, 1956. An additional 10 species may be included, to give almost complete coverage of the principal sawlog species in the local forests.

The work has not progressed to the point where definite conclusions can be drawn for each species in the study. However, laboratory experience with 37 of the island's principal sawlog species, has led to certain preliminary impressions. With the exception of two exceedingly light woods, balsa *(Ochroma lagopus* Sw.) and ceiba *(Ceiba pentandra* (L.) Gaertn.) and one exceptionally heavy wood (ausubo), the timbers are quite comparable in weight and appearance to the common sawlog species in the United States. Several species are in superficial appearance and to some extent in structure very comparable to well regarded woods growing on the mainland. Caimitillo *(Micropholis chrysophylloides* Pierre) and Caimitillo verde *(Micropholis garciniaefolia* Pierre) are similar to sugar maple *(Acer saccharum* Marsh); roble *(Tabebuia heterophylla* (DC) Britton) is similar to oak *(Quercus* spp.); tabonuco *(Dacryodes excelsa* Vahl) is similar to yellow birch *(Betula lutea* Michx.); laurel geo *(Ocotea leucoxylon* (Sw.) Mez) and laurel amarillo *(Nectandra sintenisii* Mez.) are like yellow poplar *(Liriodendron tulipifera* L.); and yagrumo macho *(Didymopanax morototoni* (Aubl.) Dcne) is like cottonwood *(Populus* spp.)

The general impression that tropical hardwoods are on the average very much heavier and harder than the hardwood of the temperate zone does not appear to be borne out in this study. It is possible that this impression has risen from the practice of utilizing principally the harder and heavier woods that are often more attractive, stronger, and more resistant to insect and fungus attack.

It is quite apparent that the tropical hardwoods growing to sawlog-size in Puerto Rico have more favorable shrinkage values than most woods of comparable density in the temperate zone. This may be in part due to the very diffuse-porous nature of the woods. The generally favorable shrinkage in volume and in ratio of tangential to radial shrinkage is likely accountable in part for the overall very favorable seasoning characteristics of the timbers under test. With the exception of one species, palo colorado *(Cyrilla racemiflora* L.), the woods appear on the average to season with less degrade than a similar group of hardwoods from the temperate zone.

The first group of 15 species was seasoned to an air-dry moisture content of 15 to 18 percent in 2 to 4 months during the least humid period of the year. The relative humidity during this period averages 60 to 70 percent, as compare to 70 to 85 percent during the wet months. This is, of course, a favorable factor in preventing degrade through too rapid initial drying. It is likely an important factor in the almost complete absence of surface checking in the timbers under test.

The humidity is, however, also a primary factor in the susceptibility of many species to attack by sap-stain fungi. This is a constant problem in Puerto Rico. Some timbers must be dipped in a fungicide solution withing a

few hours after sawing if sap-stain is to be prevented. Most species are also subject to attack by termites, powder post bettles, or pinhole borers unless protected by an insecticide. Experience in preparing test specimens of the 37 timbers and in the machining tests in progress on 15 species indicates the native timbers are, on the average, as workable as comparable woods in the temperate zone. Several woods have machined more satisfactorily than Honduras mahogany, although they are often somewhat harder and heavier and require more power to machine. It appears that a good percentage of the native timbers will machine with less defects than mahogany but that not many will machine as easily as that wood.

There appears to be a growing interest in tropical American timbers. A constantly increasing number of requests for information on timbers in the West Indies, Central America and South America were handled during the year. These include requests from branches of the Armed Services, other federal agencies, the United Nations, and from foreign governments. Some of these requests involve a special trip to Puerto Rico for those seeking information. The various agencies of the Commonwealth government now bring most of their problems in forest products to this office. In addition a considerable number of inquiries were handled for private concerns in the United States and Puerto Rico who are interpreted in marketing or utilizing the timbers in this part of the world. A heavy increase in this activity can be expected in ensuing years.

A project was begun on a compiling of the existing data for 75 present or potential commercial timbers of the Caribbean. The work is about two-thirds complete and when finished will be published as originally requested by the Timber Conference held under the auspices of the Caribbean Commission at Port of Spain, Trinidad, in April, 1953. The publication is intended to provide the interested governments, their officials and the timber users of the areas with a summary of the existing information for the principal species of the Caribbean. This is expected to be a factor in the increased sale and better utilization of Caribbean timbers. It is particularly intended to promote more trade in timbers within the region and to increase the local use of the lesser known timbers.

PUBLICATIONS

A publication entitled "Industrial wood use in Puerto Rico" by F. R. Longwood was published in Vol. 16, Nos. 3 & 4 of the Caribbean Forester. This publication presented a detailed summary of information collected during more than 500 visits to industrial concerns. It included data on the volume of wood used by species for different products and uses. Both native and imported woods were considered. The quality, grade, and prices of lumber and other wood products were presented. Other related subjects, including wood waste, plant operation, equipment, marketing and the storage of lumber were also reported on in detail. Suggestions were made for improvement in the use of both native and imported material.

Additions to the Flora of St. Barthelemy

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"A check-list of the Spermatophytes of St. Bartholomew" was published by J. Monachino in the Caribbean Forester, Vol. 2, No. 1 (1940), pp. 24-47, and No. 2 (1941, pp.49-66). The report was based chiefly on the collections of Adrien Questel, who in 1942 independently published "The flora of St. Bartholomew (French West Indies) and its origin.". (The date on the title page of Questel's Flora is 1941, but a notice on the back facing p. 224 states that the printing ended on January 21, 1942. There is also a French edition bearing the same date and pagination but not always the identical text.) In addition to the collections sent to The New York Botanical Garden and determined by Monachino, Questel listed many specimens submitted to specialists and deposited elsewhere.

Besides presenting a catalogue of the species, the Flora treated the geology, geography, phytogeography and ecology of the island and the origin and evolution of its plant life. The Check-list, on the other hand presented keys devised to identify the species by the most easily observed characters. These keys have greatly facilitated the identification of the extensive material recently collected by Pere Le Gallo. Our catalogue, to follow includes 172 species which did not appear in the Check-list: 66 of these (signaled by asterisks) are new records based on the recent collections by Le Gallo. The grand total of spontaneous vascular species reported from St. Barthélemy up to date is 598. The exploration by Questel and Le Gallo have elevated St. Barts to a rank amongst the floristically best known of the islands of the Lesser Antilles.

Approximately 440 species of wild vascular plants were enumerated by Questel. The total number cited, 509, includes cultivated plants and 17 thallophytes. In at least one instance the same species was cited separately under synonymous names *(Boerhaavia hirsuta* and *B. coccinea)*. Questel 517, named *Centrosema pubescens*, is merely a hairy form of *C. virginianum*. *Malpighia martinicensis* was reported on the basis of the collection numbered 232. But the latter number surely represents the same species as Questel 272 cited by both Questel and Monachino as *M. punicifolia*. The collection Questel 326 cited in the Flora as *Lantana camara* var. *sanguinea* (L.) Medik. was identified as *L. camara* var. *aculeata* (L.) Moldenke by Dr. Moldenke.

In addition to Questel's Flora, one other work not previously noted is worth mentioning as bearing on Sr. Barts: "Flora de la Guadeloupe et Dependences" (fasc. 1, 2, 3, published in 1937, 1948, 1949, respectively) by H. & M. Stehlé and Quentin. Eighteen of the records in fasc. 1 of this work were based on Questel's collections and were cited (Saint-Barthélemy (Questel)!" These reports were omitted by Questel in his Flora, and Le Gallo suggests that they include collections from St. Martin. The species in question are: *Fleurya aestuans* (L.) Gaud., *Phenax vulgaris* Wedd. (exclamation mark omitted in the citation by Stehlé and Quentin), *Polygonum punctatum* Ell., *Achyranthes sessilis* (L.) Standl., *Celosia argentea* L., *Microtea debilis* Sw., *Tribulus cistoides* L., *chamaesyche articulata* (Aubl.) Britton *Xylophylla epiphyllanthus* (L.) Britton, *Cardiospermum halicacabum* L., *Corchorus siliquosus* L., *Triumfetta lappula* L. *("Not found" Questel)*, *Abutilon hirtum* (Lam.) Sweet, *Hibiscus abelmoschus* L., *Malachra fasciata* Jacq., *Sida glutinosa* Commers, ex., Cav. *Sida rhombifolia* L. ("Not found" Questel), *Melochia nodiflora* Sw. ("Not found" Questel). Notwithstanding, Questel admits (Flora, p. 138) that in 1937 he gave Stehlé a few specimens and "the greater part of these species have not

been found again." *Pavonia scabra* (B. Vogel) Stehlé and Quen. was cited by Stehlé and Quentin from "Saint-Martin et Saint-Barthélemy (ex Urban)." The St. Barts' record was not located in Urban's Symb. Ant. 4 and 8. The species was not listed by Questel nor seen by Le Gallo. Stehlé in Bull. Mus. Hist. Nat. 11, 18: 187 (1946), cited *Cassia lineata* Sw. from "Saint-Barthélemy (Saint-Jean)." Stehlé and Quentin (fasc. 3, p. 22) attributed the St. Barts citation to Questel's Flora, p. 116 (French edition). That this record was founded upon an error is proved by the fact that *C. lineata* was corrected to *C. obcordata* by Questel and the latter name appears on p. 116 of the English edition of his Flora. In the same number of the Bulletin (p. 108), Stehlé also cited *(Galactia longifolia* (Jacq.) Benth "Saint-Barthélemy (Stehlé)." However, St. Barts was omitted for the species by Stehlé and Quentin in their publication of a later date (fasc. 2, p. 111). *Fleurya aestuans, Corchorus siliquosus* and *Melochia nodiflora* are the only species, of those discussed here, that have been found in St. Barts by Le Gallo.

The Check-list entered on the authority of literature species which Le Gallo recently has failed to find even after repeated search, and the presence of these on St. Barts should be regarded as doubtful: *Cassia polyadena, Margraavia umbellata, Begonia minor* ("Not found outside of the gardens" Le Gallo), *Citharexylum caudatum, C. spinosum, Tabebuia pallida, T. pentaphylla.* Questel, in his Flora, stated that *Tabebuia pallida* has disappeared completely from the island. Stehlé (Bull. So. Bot. Fr. 93: 29-36. 1946) placed *T. pentaphylla* in the synonymy of *T. heterophylla* subsp. *pallida (Miers) Stehlé. He cited* only *T. heterophylla* sensu stricto for St. Barts. *Clitoria ternata* appeared in the Check-list on the basis of Questel 329 and an Urban citation. Questel 329, however, came from a flower garden. Le Gallo has not seen the species escaped or naturalized in St. Barts. *Zanthoxylum fagara* was entered on the verbal authority of Percy Wilson; it is not supported by a specimen. Urban (Engl. Bot. Jahrb. 21: 577. 1896) cited the species under the name *Fagara pterota* L.: "St. Barthélemy ex Euphr. et Wilkstr.," but at the same time expressed his doubt regarding its presence in St. Barts. Questel noted that his specimen (unnumbered) was doubtful. Le Gallo has not been able to discover the species on the islands. The spineless form of *Z. spinifex*, recorded for St. Barts, may have been confused for *Z. fagara. Tamarix gallica* was included in the Check-list on the basis of Questel 189. According to Le Gallo, this collection was from the only specimen on the island, a tree which grew near the ancient Methodist Chapel.. With the demolishment of the Chapel, the plant has now disappeared. *Coffea arabica*, admitted on the authority of Euphrasén ex Urban, has also completely disappeared from the island, according to Le Gallo and Questel.

In the discussion under endemism (p. 31), Questel cited two species and two varieties of *Peperomia* as proper to St. Barts only. The soundness of these four taxa was suspected by the present authors. Acting on this suspicion, twelve of Questel's original specimens and one of Le Gallo's new collection, including holotypes of *P. barthelemyana, P. barthelemyana* var. *reducta*, and *P. myrtifolia* var. *major*, and an isotype of *P. questeliana* were sent for study to T. G. Yuncker, specialist on the Piperaceae. Dr. Yuncker, reported that, in his opinion, the new species are referable to two rather widely distributed older species. *P. questeliana* Stehlé and Trel. ex Stehlé is a synonym of *P. humilis* (Vahl) Dietr. *P. Barthelemyana* Trel. and its var. *reducta Trel.* are *P. myrtifolia* (Vahl) Dietr. Dr. Yuncker is inclined to think that the variation in leaf size indicated in *P. myrtifolia* var. *major Trel.* is due to only environmental condition. The island of St. Croix, only about 180 kms. from St. Barts, is the type locality of both *P. Humilis* and *P. myrtifolia.*

No novelties are described in the present work, although five taxa do not exactly conform to the typical species or to the

herbarium material at hand. See *Galactia, Croton nummulariaefolius, Jacquemontia jamaicensis, Zanthoxylum spinifex, Anthacanthus.* Also several other species were not matched precisely, as will be noted. It is anticipated that these varieties or forms will eventually be collected elsewhere in the West Indies. Probably there are no species endemic to St. Barts.

In preparing the present paper, the collections were made by C. Le Gallo in 1951 to 1955 and the taxonomy was undertaken by J. Monachino. The collection numbers cited are Le Gallo's; the species listed by Questel in his Flora are designated by Q. Le Gallo has furnished comments on the distribution of some of the species in St. Barts; these, as quoted from his letter, are indicated by the abbreviation Le G. Assistance in identification was rendered by specialists, as will be credited under the groups or species studied by them. Our particular gratitude is tendered to Dr. G. J. H. Amshoff who took almost complete charge of the Poaceae, and also aided in other families.

POLYPODIACEAE

* *Adiantum tenerum* Sw. 111, 387, 575 & 1043 (morne de Vittet).

* *Blechnum occidentale* L. 99 & 652 (morne de Vittet).

Cheilanthes microphylla Sw. 2102 (l' Orient; ca et la dans l'ile: morne de Vittet, Lurin, morne de Colombier). Q

* *Dryopteris subtetragona* (Link) Maxon. 100 & 651 (morne de Vittet; 651 abnormal with anomalous venation; det. C. V. Morton, 1953), 2135 (Vittet, morne, rochers, 150-220 m.).

Pityrogramma calomelanos (L.) Link. 108 & 648-B (morne de Vittet). Q.

Pityrograma schaffneri (Fée) Weatherby. 104 & 962 (Ilet Frégate), 530 (Grand Cul de Sac), 1038 (Vittet), 1067 (Grand Platon; det. of this coll. confirmed by C. V. Morton, 1953), 2033 (Petite Saline), 2088 & 2089 (Ilet Frégate), 2182 (Grand Platon), 2287 (Ilet de Toc Vert). Q.

Polypodium aureum L. 110 & *202 (morne de* Vittet), 560 (morne entre St. Jean et Grand Saline), 648 (morne de Vittet), 809 (morne de Saline). Q.

* *Polypodium heterophyllum* L. 2117 & 2170 (Vittet), 2245 (morne de Grand Fond), 2457 (morne de Vittet).

Polypodium polypodioides. (L). Watt. 532 (fond de l'anse de l'Orient), 2109 (Vittet, morne, rochers, 200 m., rare dans l'ile.). Q.

PSILOTACEAE

* *Psilotum nudum* (L.) Griseb. 2172, 2192, 2197 & 2350 (Petite Saline; deux localites connues, Petite Saline et L'Etoile).

POACEAE

(Le Gallo specimens determined by G. J. H. Amshoff, unless otherwise noted)

Aristida adscencionis L. 978 pro parte (St. Jean), 1055 (Grand Platon). Q.

* *Aristida cognata* Tr. & Rupr. 10 (Ilet de Frégate), 26 (Coupe-Gorge), 940 & 947 (Pointe de Chauvette; 947 imperfect, doubtful), 954 (Ilet de Frégate).

Aristida eggersii Hitch. Q.

* *Aristida swartziana Steud.* 3 & 597 (morne du Grand Galet).

* *Bothrichloa ischaemum* (L.) Keng. = *Andropogon ischaemum* L. 1027 (Chauvette).

Bothrichloa pertusa (L.) A. Camus = *Andropogon pertusus* (L.) Willd. 2223 & 2233 (l'Orient). Q.

* *Bouteloua vaneedenii* Pilger. 303 *(morne* de Petite Saline), 314 (Morne de Grand Fond), 966 (between Saline and Seine Anglais), 1079 (Mangeant), 2542 (Pointe de Mangeant, rocailles, 70 m. alt.; det. Monachino).

Cenchrus echinatus L. 988. Q.

Cenchrus pauciflorus Benth. 18 (St. Jean). Q.

* *Chloris ciliata* Sw. 985 & 986 (près du prestère de l'Orient).

Chloris inflata Link. Q.

Chloris virgata Sw. Q.

Cynodon dactylon (L.) Pers. Q. Reported by Le Gallo (in letter).

* *Digitaria bicornis* (Lam.) R. & S. 397 (Mangeant), 1029 pro parte (Pointe de

Chauvette), 1097 (morne de Public; det. Henrard).

Digitaria horizontalis Willd. 21 & 222 pro parte ("spreading long hairs lacking, distinctly developed rachis present" Amshoff). Q.

**Digitaria longiflora* (Retz) Pers. 958 (pentes du morne Larigot), 1052 (Mangeant), 1056 bis.

Eragrostis amabilis (L.) Wight & Arn. 2433 (St. Jean; det. Monachino). Q.

Eragrostis ciliaris (L.) Link. Q. Also collected by Le Gallo in Anguilla (2518; det. Monachino).

Eragrostis purpurascens (Spreng.) Schult. 981 (pentes du morne Larigot), 2384 (St. Jean; det. Monachino). Checked by J. R. Swallen, who wrote in August, 1953; "Le Gallo 981, is the same as Questel 790, which has been identified as *E. purpurascens* (Spreng.) Schult. I believe there is some question as to whether this is actually the same as *Poa purpurascens* Spreng. This is the best disposition that can be made of it at the present time. LeRoy Harvey, in his revision of North American E*ragrostis*, University Microfilms (Michigan) Pub. 967, cites Questel 790 under this species." Q.

Heteropogon contortus (L.) Beauv. 480 (St. Jean), 570, 700 & 1023 (Chauvette). Q. Also collected by Le Gallo in Anguilla (2521; det. Monachino).

Lasiacis divaricata (L.) Hitchc. 9 (morne de St. Jean; sterile), 496 & 701 (morne a Diaquot), 510 (l'Orient), 547 (Petite Saline), 548 & 549 (morne Etoile), 595 (Monte au Ciel; sterile), 1096 (l'Orient). Q.

Panicum adspersum Trin. 4 (road to Grand Fond), 225 pro parte (Monte au Ciel), 596 (road to Grand Fond). Q.

Panicum barbinode Trin. Q.

Panicum fasciculatum Sw. 969 (St. Jean).

Panicum utowanaeum Scribn. Q.

* *Pappophorum pappiferum* (Lam.) Kuntze. 5 & 13 (Rock of the Castle), 312 (morne de Grand Fond), 508 (Chauvette), 452 (Anse de Cayes), 512 pro parte (l'Orient), 946, 949, 950 & 951 (Ilet de Frégate).

* *Paspalidium geminatum* (Forsk.) Stapf. 198 pro parte & 979 pro parte (St. Jean).

Paspalum laxum Lam. Q. Also collected by Le Gallo in Anguilla (2516; det. Monachino).

* *Paspalum secans* Hitch. & Chase. 1021 (Pointe de Chauvette).

* *Rhynchelytrum roseum* (Nees) Stapf. 506, 588, 704, 937, 1022 & 1024 (Chauvette).

* *Schizachyrium gracile* (Spreng.) Nash. 316 (morne de Gran Fond), 1059 (Grand Platon), 1098 (Morne de Public).

* *Setaria geniculata* (Lam.) Beauv. 1060 (Grand Platon).

* *Setaria rariflora* Mikan apud Trin. 8 & 54 (Mangeant).

* *Setaria verticillata* (L.) Beauv. 2241 & 2242 (cultures, plateau de Vittet).

Spartina patens (Ait.) Muhl. Q.

Sporobolus indicus (L.) R. Br. 1 (l'Orient), 26 (Coupe-George), 270 (l'Orient), 970 pentes du morne Larigot), 979 pro parte (St. Jean). Q. Also collected by Le Gallo in Anguilla (2519a; det. Monachino).

Sporobolus pyramidatus (Lam.) Hitchc. 953 (Ilet de Frégate), 963, 965 & 978 pro parte (St. Jean). Q. Also collected by Le Gallo in Anguilla (2519; det. Monachino).

* *Sporobolus poiretii* (Roem. & Schult.) Hitchc. 979 pro parte (St. Jean).

* *Sporobolus tenuissimus* (Schranck) Kuntze. 57 (l'Orient, près de la citerne du presbytère).

Tragus berteronianus Schult. Q. Appeared in the Check-list as *Nazia aliena* (Spreng) Scribn. Also collected by Le Gallo in Anguilla (2520; det. Monachino).

CYPERACEAE

**Bulbostylis antillana* (Britton) Fernald. 1065 (seulement au Grand Platon).

* *Cyperus articulatus* L. 976, 2071, 2309 & 2310 (Ilet Fourchu).

**Cyperus calcicola* Britton. 2374 & 2378 (St. Jean, Lieux sableux, dune, 3 m.; achene 1.15 mm. long, 0.66 mm. broad). The specimens are very poor. Good material was collected by Le Gallo in Saint Martin (1005, ilet de Tintamarre) and Anguilla (2501); spikelets spreading and forming globose heads, not reflexed, scales few, faintly striate, achenes 1.33 mm. long. The type (at NYBG) was named *C. fuligineus* Chapm. by Hugh O'Neill. The species should also be critically studied as possibly involving *C. nanus* var. *subtenuis* Kükenth. (e.g., see Britton et al. 1741, Mona Island, and 4694, Punta Aguila, Porto Rico).

Cyperus confertus Sw. 296 (château), 346 (morne de Colombier; det. Amshoff), 374, 463 & 466 (Mangeant), 994 (mornes de Public), 1032 (Chauvette), 1053 & 1078 (Mangeant), 2015 (Pointe Felix), 2340 (l'Orient), 2437 (St. Jean), 2449, 2461 & 2462 (l'Orient). Q.

Cyperus elegans. L. 240 (St. Jean), 405 & 407 (Gustavia), 591 & 716 (St. Jean), 781 (morne Larigot; det. Amshoff). 1074 (St. Jean), 2007 pro parte (morne Larigot; det. Amshoff), 2312 (Ilet Furchu), 2459 (Vittet). Q. Note: 405 & 716 are forms with extremely slender culms and leaves.

* *Cyperus laevigatus* L. 1073 (St. Jean).

Cyperus nanus Willd. 1089 (Larigot; det. Amshoff), 2262 (Tiberry, petite Saline), 2289, 2305 & 2306 (Larigot). Q. The Wikstrom record from St. Barts reported by Grisebach as *C. tenuis* Sw. appears to be referable to this species.

Cyperus oxylepis Nees. 22 (St. Jean), 404 (Gustavia), 472 & 598 (St. Jean), 684 (Gustavia), 750 (Grande Saline; det. Amshoff), 805 (Larigot), 2007 pro parte (morne Larigot; det. Amshoff), 2341 (morne Larigot). Q.

Cyperus planifolius L. C. Rich. 2 (entre St. Jean et Saline), 6 (St. Jean), 12 (Mangeant; det. Amshoff), 14 (l'Orient), 19 (morne de Colombier; det. as. *C. brunneus* Sw. by Amshoff), 21, 25 & 150 (St. Jean; det. as *C. brunneus* Sw. by Amshoff) 151 (St. Jean), 152 (Gustavia; det. Amshoff), 317 (Grande Saline), 318 (morne de Grande Saline; det. Amshoff); 328 (morne de Colombier; det. Amshoff), 357 (Chauvette), 639 (Grande Saline), 813 (Larigot), 814 & 815 (Flamands), 939, 1018 & 1035 (Chauvette), 1069 (St. Jean-Saline), 2272 & 2275 (St. Jean), 2288 (Ilet de Toc Vert). Q. (as *C. brunneus Sw.)* Note: *Mariscus brizaeus* (Vahl) Clarke (= *C. brunneus* Sw.) was reported by Urban. *C. brunneus* Sw. was placed in the synonymy of *C. planifolius* by Hugh O'Neill (1946). The specimen of *C. planifolius* from St. Barts have the rays of the umbels elongated, the inflorescence more diffuse than is usual for the species.

Cyperus rotundus L. 7 (l'Orient), 17 (Grand Fond), 241 & 593 (l'Orient). Q.

* *Eleocharis caribaea* (Rottb.) Blake. 226, 470, 590, 974, 2263, 2264, 2278 & 2279 (St. Jean).

Fimbristilys spathacea Roth. 354 (Saline), 403, 434 & 1070 Gustavia. Q. Note: 1070 is a form with diffuse umbels and narrow leaves.

* *Scleria lithosperma* (L.) Sw. 447 (morne de l'Etoile; det. Amshoff), 807 & 823 (Larigot), 2034 (Petite Saline). Also collected by Le Gallo in Saint Martin (902) and Anguilla (2503).

ARECACEAE

Sabal prob. *causiarum* (O. F. Cook) Becc. "naturalized; seeds introduced some 50 years ago" Q. "Anse aux Flamands, Grand Fond, Anse Toiny" Le G.

Sabal questeliana L. H. Bailey, Gent. Herb. 6 (7): 422. 1944. Questel s. n., St. Barts; said to have been introduced more than 50 years ago from the Turks Islands in southern Bahamas. "Très répandu dans toute l'ile" Le G.

Coccothrinax sp. Q. "Largement répandu mais beaucoup moins que *Sabal questeliana.* Je pense que *Coccothrinax* a été introduit de Guadeloupe. On ne le trouve

pas dans les lambeaux de forêt ancienne mais sourtout on recontre non loin des lieux habités" Le G.

LEMNACEAE

Lemma perpusilla Torr. Q. "çà et la dans les mares de l'ile". Le G.

BROMELIACEAE

* *Dendropogon usneoides* (L.) Raf. 227 & 2030 (Petite Saline), 2079 (Grand Fond).

* Unidentified. 2261 (L'Orient, taillis, 90 m. env.). Sterile; new recorded for the island. The ensiform leaves are about 60 cm. long and 3.5 cm. broad, finely spinulose serrulate on the margins.

COMMELINACEAE

Callisia repens L. Q.

LILIACEAE

Aloe vera L. "naturalized" Q. "Largement naturalisé dans toute l'ile" Le G.

AMARYLLIDACEAE

Agave dussiana Trel. Q. (det. Trelease). "Fréquents" Le G.

Agave sisalana Perrine. Q. (det. Trelease). "Fréquents" Le G.

Crinum amabile Donn. "Naturalized" Q. "Ne s'eloignent guère des jardins" Le G.

Furcraea tuberosa Ait. Q. (det. Trelease). "Plutôt rare" Le G.

Zephranthes carinata (Spreng.) Herb. "Escaped" Q. "Ne s'eloignent guère des jardins" Le G.

Zephrantes aurea Baker. "Escaped" Q. "Ne s'eloignent guère des jardins" Le G.

ORCHIDACEAE

Epidendrum bifidum Aublet. 812 (morne Larigot), 1000 (Merlette), 2022 (Roche Marrone), 2086 (Anse Chauvette), 2175 (Anse de Cayes), 2262 (Merlette). Q Charles Schweinfurth wrote in September, 1954 that after critical study he decided that 1000 and 2022, as well as 2175 which previously he had reported as *E. olivaceum* Cogn., are referable to the variable *E. bidifum*. Questel 360 also should be referred to this species. Le Gallo noted that almost all the *Epidendrum* on the island are like 2175; the species is quite common on exposed rocks.

**Oncidium intermedium* Bertero ex Spreng. 128 (morne a Diaquot, Vittet), 810 (morne Larigot) 2389 & 2392 (morne a Poune). Le Gallo 2389 was checked by Charles Schweinfurth, April, 1956. Questel cites *O. guttatum* (L.) Reichb. f. for St. Barts (Le Rhin), but the species may be this instead.

Stenorrhynchus orchioides (Sw.) L. C. Rich. Q. "Malgré toutes mes recherches, surtout auprès des petites mares de St. Jean, je n'si jamais vie cette plante a St. Barth." Le G. The Questel St. Barts' record is not supported by any specimen in the herbaria at N. Y. Bot. Gd., Harvard, and U. S. Nat. Mus.

URTICACEAE

Fleurya aestuans (L.) Gaud. 2376 (on walls, presbytère, Gustavia, 1 Janv. 1955). "(Questel)!" Stehlé & Quentin 1:184. Not in Q.

OLACACEAE

Schoepfia schreberi J. F. Gmel. 728 (sentier entre Vittet et Grand Fond), 787 (chemin de Vittet a Grand Fond), 2074-2076, 2375, 2377 and 2379 (St. Jean). Q. A sterile specimen previously collected by Forsstrom is probably of the same species.

POLYGONACEAE

Coccoloba venosa L. = *C. nivea* Jack 2325, 2327, 2328 & 2371 (St. Jean; very rare, seen at one place; 2371 checked by R. A. Howard).

CHENOPODIACEAE

Chenopodium ambrosioides L. Q. "Naturalisé autour des habitations" Le G.

AMARANTHACEAE

Achyranthes repens L. 33 & 102 (l' Orient). Q.

Achyranthes urbani Standl: 106 (Ilet de Frégate, en face de l'Orient), 233 (anse de

l'Orient), 542 (Mangeant). The staminodes were examined in 106 and 233.

Iresine celosia L. 385 (Vittet), 390, (Mangeant), 408 (Anse Gouverneur), 677 (Vittet), 711 (l'Orient), 2347 (Vittet). Q.

NYCTAGINACEAE

Mirabilis jalapa L. "Escaped" Q.

Pisonia subcordata Sw. 131 & 641 (Chemin de l'Orient a Gustavia, St. Jean). Q.

PHYTOLACCACEAE

Trichostigma octandrum (L) H. Walt. Q. "General dans l'ile, mais de place dans les coulées ambreuses ou les crevasses des mornes" Le G.

AIZOACEAE

Mollugo verticillata L. 103 (Grand Fond), 393 (Mangeant,) 465 (Frégate), 2164 (Grand Fond), 2231 & 2232 (Mangeant).

Sesuvium maritimum (Walt.) B.S.P. Q.

PORTULACACEAE

* *Talinum paniculatum* (Jacq.) Gaertn. 273 (seulement ã morne de Vittet).

PAPAVERACEAE

Argemone mexicana L. Q. "Trés commune comme rudérale dans toute l'ile" Le G.

BRASSICACEAE

Lepidium virginicum L. Q."Général" Le G.

CAPPARIDACEAE

Capparis coccolobifolia Mart. 205 & 2047 (l'Orient, Diboque). Q.

Cleome gynandra L. Q. "Occasionnelle, l'Orient, Corossol" Le G.

* *Morisonia americana* L. 193 (l'Orient, vieux chemin de Grand Fond), 267 (morne de Petite Saline), 2046 & 2048 (l'Orient, 2080 & 2060 (l'Orient, Diboque).

CRASSULACEAE

Bryophyllum pinnatum (Lam.) Kurz. Q. "Général et commun par places" Le G.

AMYGDALACEAE

Chrysobalanus icaco L. Q. "St. Jean, Grande Saline, Anse des Cailles, morne de Petite Saline, morne de Vittet" Le G.

MIMOSACEAE

Acacia guadalupensis DC. 433 (l'Orient), 610 (morne de Petite Saline). Previously collected by Questel at St. Jean and reported as *A. riparis* H.B.M.

CAESALPINIACEAE

Cassia bicapsularis L. 384 (Vittet), 519 & 727 (près cimetière de St. Jean).

* *Cassia chamaecrista* L. 457 (St. Jean, fide Amshoff), 2444 (St. Jean), 2523 (Sirène, hauteurs Saline), 2535 (St. Jean), 2552 & 2553 (Grande Saline), 2561 (St. Jean).

* *Cassia emarginata* L. 130 (Anse Toiny), 379 (Vittet), 755, 791 & 982 (Anse Toiny), 756, 757 & 775 (Anse Toiny, fide Amshoff).

Cassia glandulosa var. *swartzii* (Wikstr.) Macbride. St. Barthélemy is the type locality.

Cassia obcordata Sw. ex Wikstr. 418 (Vittet), 553 & 579 (morne entre Saline et St. Jean), 660 (Châteu), 693 (St. Jean), 2308 (Ilet ouest de Fourchu). Q.

Cassia occidentalis L. Q. "Commun" Le G.

Delonix regia (Bojer) Raf. "seen" Q. "naturalisé" Stehlé l. c. 186.

Haematoxylon campechianum L. 368 (Gustavia). Q.

Hymenaea courbaril L. 583 (morne du Rhin). Q.

FABACEAE

* *Aeschynomeme americana* L. 370, 482 & 2198 (l'Orient 2522), 2545, 2559 & 2560 (Grande Saline). 370 was checked by Velva E. Rudd; 482, fide Amshoff.

* *Crotalaria lotifolia* var. *eggersii* H. A. Senn. 376 & 394 (Mangeant), 419 (Anse Toiny), 528 (Grande Saline), 679 (Mangeant), 956 (Seine Anglais), 1017 & 1050 (Chauvette), 2035 (Mangeant), 2166 & 2213 (Cul de Sac).

Desmodium canum (Gmel.) Schinz & Thellung. 545 (Petite Saline), 669 (morne de Vittet), 2040 (Petite Saline). Q (as "*D. supinum* DC.").

* *Desmodium scorpiurus* (Sw.) Desv. 1045 pro parte (Vittet).

Desmodium tortuosum (Sw.) DC. 171 (Anse

de l'Orient), 2324 (Vittet), 2388, 2427, 2429, 2438, 2439 & 2445 (Mangeant). Q.

* *Galactia dubia* DC. 2083 (Anse Gouverneur), 2155 (Grand Fond), 2234 (Coupe-Gorge), 2236 (Grand Saline).

Galactia sp., variety of *G. dubia* DC? 369 (L' Orient, 25 Jan. 1952), 371 & 540 (Mangeant, 17 Jan. 1952), 818 (rochers près de l'Anse aux Flamands, 4 Juin 1952), 1026 & 1028 (pointe de Chauvette, rochers maritimes, ca. 20 m. alt., 30 Sept. 1952), 2220 (Vittet, rochers basaltiques, 170 m., 15 Nov. 1953), 2268 (Anse á Toiny, falaises, entre rochers, 15 m., 11 Juil 1954), 2286, 2302, 2387, 2426, 2450, 2528, & 2534 (Marigot, sur murette á Sisal, 30-70 m., Sept. 1954,Nov. 1955). The members of *G. dubia* complex are very variable in leaflet size and shape, in pubescence, and also in the width of the legume. A critical study of the species and its allies is required. The St. Barthèlemy specimens are 3-foliolate (some individual leaves possibly unifoliolate), the leaflets oval or orvicular to obovate, 1-2.8 cm. long, usually emarginate at apex, glabrous above except for a line of hairs on midrib, silvery strigulose beneath, hairs dense and closely appressed, the young stems similarly silky; flowers and buds 1-4 to each inflorescence, the calyx appressed white-hairy, the legumes 2.5-4.5 mm. broad, white-pubescent with mostly appressed hairs. The leaf-pubescence suggest some material of the unifoliolate *G. numularia Urban* from St. Martin. Our plant somewhat also suggests *G. uniflora* Urban from the Bahamas. According to Fawcett & Rendle (Fl. Jamaica), the latter is possibly only a small form of *G. dubia*.

Piscidia piscipula (L.) Sarg. Q. "L'un des arbustes les plus communs de St. Barthèlemy" Le G.

* *Teramnus* labialis Spreng. 426 &713 pro parte (l'Orient).

ERYTHROXYLACEAE

Erythroxylon brevipes DC. "Forsstrom (hb. holm.); = *E. ovatum Eggers, non* Cav." O. E. Schulz in Urb. Symb. Ant. 5: 207. 1907.

ZYGOPHYLLACEAE

Guaiacum officinale L. 427 (l'Orient), 555 (taillis a Cactacées et Acacias, Coupe-Gorge). Q.

RUTACEAE

Citrus aurantifolia (Christm.) Swingle. "Naturalized" Q.

Zanthoxylum spinifex (Jacq.) DC. 786 (chemin de Vittet, a Grand Fond, 20 Mars 1952). Q. The Le Gallo specimen is a form or variety without spines; stems not as strongly zig-zag as is usual for the species.

SURIANACEAE

Suriana maritima L. Q. Forsstrom. "St. Jean, l'Orient, Marigot, Anse Toiny, Grand Fond, etc." Le G.

BURSERACEAE

Bursera gummifera L. Q. "Commun" Le G.

MALPIGHIACEAE

* *Stigmaphyllon diversifolium* (H.B.K.) A. Juss. = *S. ledifolium* (H.B.K.) Small. 808 (morne Larigot), 2212 (Cul-de-sac), 2247 (Petite Saline), 2276 (St. Jean). The two specific spithets were published in *Banisteria* on the same date and page. The taxa were first united by Jussieu (Monographie Malpig. 1844), and his choice of name must be followed (Article 67 of the International Code, 1952).

EUPHORBIACEAE

Acalypha chamaedrifolia (Lam.) Muell. Arg. Q.

* *Aklema petiolaris* (Sims) Millsp. = *Euphorbia petiolaris* Sims. 2171 (l'Orient).

* *Croton nummulariaefolius* A. Rich. 304 (morne a Poune, 3 Oct. 1951), 313 (morne de Grand Fond, rochers, 250 m. alt. 11 Oct. 1951), 534 (Chauvette, 25 Oct. 1951), 640 (Morne de Grand Fond, rochers, 250 m. alt., 11 Oct. 1951), 718 & 724 (au dessus du Grand Platon, pres

de Grand Fond, sur rochers, 14 Mars 1952), 1062, 1063, 1064 and 1068 (Grand Platon, rocailles, rochers dacite, 150-200 m. alt., 30 Oct. 1952), 2081 & 2082 (Grand Fond, rochers, falaises du Grand Platon, 100 m., 15 Apr. 1953). Form or variety with pubescence-stellae on stem closer, rays shorter, center ruby-brown; pedicels very short; sepals in fruiting specimens substapulate, narrowed at base, about 1.8-2 mm. long.

Chamaesyche hypericifolia (L). Millsp. = *Euphorbia hypericifolia* L. 246 (l'Orient). "Given to M. Stehlé in 1937" Q. "Saint-Barthélemy (Questel)!" Stehlé & Quentin 1:68.

* *Chamaesyche thymifolia* (L.) Millsp. = *Euphorbia thymifolia* L. 2178 (St. Jean, terrains sablonneux bord de la mer), 2226 (St. Jean, jardin près d'un rocher). Fruits with longer more spreading hairs than is usual for the species.

Euphorbia tirucalli L. "Escaped & subspontaneous" Q.

* *Gymnanthes lucida* Sw. 98 (morne de l'Etoile), 258 & 619 (morne de Vittet), 653 (morne de l'Etoile), 799 (Vittet, mornes de Dévet), 1080 (l'Orient.)

Hippomane mancinella L. Q. "Commun sur le bor des plages et parfois a l'intérieur du pays" Le G.

Phyllanthus swartzii Kostel. Questel specimens previously named *P. niruri* L. were determined as *P. swartzii* by Grady L. Webster in 1953.

Ricinus communis L. Q.

SAPINDACEAE

Melicocca bijuga L. Q.

* *Sapindus saponaria* L. 30 (morne de Vittet, bois Chapelet, Simonet), 559, 699 (morne de Vittet).

RHAMNACEAE

Colubrina ferruginosa Brong. 521, 524 & 529 (Cul de Sac, rochers madréporiques au dessus de la grande Voute), 717 & 721 (Anse Maréchal, bordure de la mer), 735, 737 & 784 (Cul de Sac, rochers madréporiques au dessus de la grande voute), 789 (Grande Saline), 792 (Cul de Sac, la grande Voute, rochers calcaires), 804 (Cul de Sac, au dessus de la Grande Saline).

Colubrina reclinata (L'Her.) Brongn. 254 (fond de l'Anse, l'Orient, rochers), 259 (Anse de l'Orient), 561 (fond de l'Anse, l'Orient), 572 (mornes au fond de l'Orient), 577 l'Orient), 622 (fond de l'Anse, rochers), 663 (mornes de Saint Jean), 702 (Vittet, morne a Diaquot), 788 (Grande Saline, rochers), 999 (Anse aux Gascons), 2019 (Vittet) 2332 & 2349 (Mangeant). Note: 702 & 2349 *(C. reclinata)* and 784 & 804 *(C. ferruginosa)* are flowering specimens fairly typical of the species. The other collections cited under *C. reclinata* are without open flowers, and some of then may actually be shade forms of *C. ferruginosa.* The two species are quite similar in essential details and perhaps not clearly distinct.

Krugiodendron ferreum (Vahl) Urb. 172 (morne, environ de l'Orient), 203 (morne de Vittet), 301 (morne de Petite Saline), 574 (L'Orient, morne au dessus de l'Ecole), 576 (morne de Vittet), 580 & 582 (Le Rhin, entre Anse Gouverneur et Gustavia), 666 (morne de Vittet, flanc nord), 798 (Grande Saline, mornes).

VITACEAE

Cissus sicyoides L. Q. "Commun partout dans l'ile" Le G.

TILIACEAE

Corchorus siliquosus L. 432 (Anse Gouverneur), 2024 (Chemin de Saline - Lurin), 2352 & 2533 (Lurin). "(Questel)!" Stehlé & Quentin 1:117. Not in Q.

MALVACEAE

Abutilon indicum (L.) Sweet. 422 (L'Orient).

Gossypium hirsutum L. "Spontaneus" Q.

Paritium tiliaceum (L.) A. L. Juss. 622 (En bordure de l'Anse de l'Orient).

Sida aggregata Presl. Q.

BOMBACACEAE

Ceiba pentandra (L.) Gaertn. "Only two or three large trees remain" Q.

STERCULIACEAE

Melochia nodiflora Sw. 421, 687 & 697 (l'Orient, Diboque). "(Questel)!" Stehlé & Quentin 1:114. "Not found" Q.

CANELLACEAE

* *Canella winterana* (L.) Gaertn. 2551 (Lurin, taillis, 150 m. env.; sterile).

VIOLACEAE

* *Hybanthus caribaeus* Urb. 729 (Marigot), 934 (Anse Chauvette), 957 & 978 (Saint-Caillu, parmi Crotons et Cactées), 1019 1020 & 1030 (pointe de Chauvette), 2012 (Pointe Felix). Doubtfully distinct from *H. linearifolius;* 729 & 978 conform rather closely with a syntype of *H. Caribaeus* (Duss 2959). The leaves and habit are variable.

Hybanthus linearifolius (Vahl) Urb. Q.

Hybanthus portoricensis Urb. 377, 462 & 464 (Mangeant), 519 & 531 (Grand Cul de de Sac, pointe du Vente). Both this species and *H. caribaeus* need study. Le Gallo suspects that *Hybanthus in St.* Barts modifies its size according to habitat. In very sunny, dry, rocky soil it is small, hardly a few centimeters in length. In the shade or in the *Opuntia* brush, it measures about one or two centimeters. Both the small and the large specimens have flowers with a yellow spot in the center and pale rose-colored lower petal.

PASSIFLORACEAE

Passiflora foetida L. "Gustavia, Anse des Cayes, camaruche" Le G.

CARICEAE

Carica papaya L. "Subspontaneus" Q.

CACTACEAE

Cereus intortus Mill. Q. "Commun" Le G.

Cephalocereus nobilis (Haw.) Britt. & Rose. Q. "Très commun" Le Gallo.

Consolea rubescens (Salm-Dyck), Lemaire. Q. "Dans les caps escarpés, rocailleux" Le G.

Neomammilaria nivosa (Link) Britt. & Rose. Q. "Ilets Fourchu, Coco, Frégate, Pointes Colombier, Mangeant, Toiny, etc." Le G.

Opuntia dillenii (Ker-Gawl) Haw. Q.

Opuntia triacantha (Willd.) Sweet. Q.

Opuntia tuna (L.) Mill. Q.

MYRTACEAE

Anamomis fragrans (Sw.) Griseb. 182 (Grand Voute a Mangeant), 250 morne a Diaquot), 381 (Vittet; sterile), 565 (morne á Diaquot), 633 (Grande Voute a Mangeant), 636 (morne de Petite Saline), 676 (Vittet; sterile), 1083 (St. Jean).

* *Eugenia cordata* (Sw.) DC. 471 (morne de St. Jean; sterile; reported by Amshoff), 587 (morne entre Saline et St. Jean), 819 (Morne Larigot), 996 (Petite Saline), 1091 (Morne Larigot), 2023 (Petite Saline), 2027 (Petite Saline; sterile; reported by Amshoff), 2201 (morne de Petite Saline).

* *Eugenia maleolens* Pers. 428 & 431 (Anse Gouverneur; former reported by Amshoff), 1087 & 1088 (Grand Bois), 2041 mornes de l'Etoile). It appears that the familiar name *Eugenia buxifolia* (Sw.) Willd. (1800) of the West Indies must be discarded, for it is a later homonym of *E. buxifolia* Lam. (1789) described from Reunion. If Urban's synonymy in Engl. Bot. Jahr. 19:637 (1895) is correct and complete, our plant must be called E. *maleolens* Pers. (1087).

Eugenia monticola (Sw.) DC. Q (877, wooded hillsides, St. Jean.) "Pass encore vu dans les collines foisées St. Jean, j'ai vu *E. ligustrina E. rhombea*, et alors *E. buxifolia*" Le G.

* *Myrtus orbicularis* (Berg) Burret. 525, 733, 793, 1042, 1047 & 1048 (Cul de Sac, Grande Voute, rochers madréporiques). 1047 was compared with L. C. Richard's type of *Eugenia orbicularis* Berg at Paris by M. Pichon who reported: "Je puis vous affirmer que l'identité des deux est

complète." Le Gallo also collected the species in Anguilla (2492, 2508). *M. anguillensis* Urban appears to be conspecific. Amshoff communicated: "*Myrtus orbicularis*, represented in the collection of Le Gallo by the nrs. 1047 and 2067, is indeed conspecific with *Myrtus anguillensis* Urban. I have now seen specimens from Anguilla, St. Barts and the Dutch West Indies."

COMBRETACEAE

Terminalia cattapa L. Q. "La plante se naturalisé lentement" Le G.

APIACEAE

Foeniculum vulgare Mill. "Naturalized" Q.

THEOPHRASTACEAE

* *Jacquinia berterii* Spreng. 1058 & 1066 (Grand Platon, dans rochers, bois, tailles).

SAPOTACEAE

Bumelia obovata (Lam.) A. DC. 120 (mornes de St. Jean, bois de Monte au Ciel), 293 & 606 (mornes environs de l'Orient), 618 (sommet du morne de Vittet), 642 (mornes de St. Jean), 731 (chemin entre Vittet et Grand Fond), 2118 (Cul-de-Sac), 2125, 2126, 2134 & 2156 (l'Orient). Forsstram.

Manilkara zapotilla (Jacq.) Gilly. "Subspontaneous" Q.

OLEACEAE

Jasminum azoricum L. 566 (haies, chemin de l'Orient). "Escaped" Q.

APOCYNACEAE

* *Urechites lutea* (L.) Britton. 526 (Anse Toiny), 803 (Cul de Sac, dessus Grande Voute), 681 & 734 (Anse Toiny), 794 (Anse a roches basaltiques), 972, 992 & 993 (mornes de l'Anse a Toiny), 1049 Anse Toiny).

CONVULVULACEAE

* *Calonyction tuba* (Schlecht.) Colla. 2176 (Anse aux Lézards; seule localité connue).

Evolvulus glaber Spreng. 129 (route de Saline), 397 pro parte (St. Jean), 494 (Vittet, morne a Diaquot), 527 (Cul de Sac, dessus de la Grande Voute), 539 (Mangeant), 544 (Petite Saline), 726 pro parte (près cimetière de St. Jean), 983 (terrains rocailleux), 2139 (Marigot), 2207 (l'Crient). Q.

Evolvulus nummularius L. 2142 & 2169 (Anse aux Lézards), 2177 (Anse de Cayes).

Evolvulus sericeus Sw. 315 (Grande Saline), 935 (Chauvette), 964 (entre Saline et Seine Anglais), 968 (morne Larigot), 977 (près Seine Anglais), 1033 (Pointe de Chauvette), 2098 (l'Orient), 2110 (Pichotte), 2227 & 2323 (Mangeant). Q.

Exogonium solanifolium (L.) Britton. 359 (Chauvette), 1084 (Camaruche), 2193 (l'Orient). Q.

Ipomoea nil (L.) Roth. Q. "Cá et lá" Le G.

Ipomoea pes-caprae (L.) Roth. Q. "Très commun du bord de mer autor de l'ile" Le G.

* *Ipomoea quinquefolia* L. 2173 & 2200 (l'Orient, found once).

Ipomoea triloba L. Q. "Cá et lá" Le G.

* *Jacquemontia jamaicénsis* (Jacq.) Hall. f., var. 742 (Pointe la Caye, Anse de Cayes, 18 Mr. 1952), 743 (Anse de Cayes, bord de la mer, O m., 18 Mr. 1952), 2145 (Anse aux Lézards, rochers maritimes, 10 m., 10 Dec. 1953), 2174 (Anse de Cayes, rochers maritimes, 20 m., 10 Dec. 1953; only one locality known.) The shape and texture of the leaves and the habit of the plant are as in *J. cayensis* Britton; our variety differs in the marked density of leaf indumentum. At least three species are involved, the two already mentioned and *J. reclinata* House ex Small. It is suspected that these species comprise but a single variable one with several races, forms or varieties. The Le Gallo specimens were not matched with any material at The New York Botanical Garden.

Jacquemontia nodiflora (Desr.) G. Don. 397 St. Jean), 2195 (Cul de-Sac), 2202, 2216 & 2246 (Petite Saline).

Jacquemontia obcordata (Millsp.) House, N. Y. Mus. Bull. 233-234:63 (1921) =

Convolvulus obcordatus Millsp., Columb. Mus. Bot. 2:88 (1900) = *Jacquemontia subsalina* Britton, in Britton & Wilson, Sci. Surv. Porto Rico and Virgin Islands 6: 106 (1925). 2253 (l'Orient près du presbytére, 15 m., 12 Mars 1954). Questel 373 (Grande Saline, 1938), cited in the Check-list as *J. ovalifolia (Vahl)*, Hall. f., is the same. It has not been possible to check the type of *Convolvulus ovalifolius* Vahl.

Operculina dissecta (Jacq.) House. 294 & 607 (L'Orient; assez commun dans les halliers de toute l'ile). Q.

HIDROPHYLLACEAE

Nama jamaicensis L. Q.

BORAGINACEAE

Cordia dentata Poir. Q (as "*Cordia alba*" in the Flora) cited by Johnston.

Cordia glabra L. Q.

Cordia globosa (Jacq.) H.B.K. 563 (chemin de Camaruche). Q.

Cordia myxa L. "*Escaped*" Q. "En voie de naturalisation non loin des lieux habités." Le G.

Cordia sebestena L. Q. "Rarement échappé (Anse de St. Jean)" Le G.

* *Heliotropium microphyllum* Sw. ex Wikstr. 2093 &2225 (Pointe des Nègres, falaises calcaires du littoral; a very rare plant on the island). Four Urban species are placed in the synonymy of *H. microphyllum* by Johnston. Our plant also matches fairly well with specimens of *H. imbricatum Griseb.* from Cuba and *H. inaguense* Britton from the Bahamas.

Heliotropium parviflorum L. 188 (Anse de l'Orient). Forsstrom. Q.

* *Rochefortia acanthophora* (DC.) Griseb. 806 (Pointe Blandin taillis), 2386 (Marigot, taillis, 70 m. environ).

Tournefortia microphylla Bert. ex Spreng. 268 & 614 (près du presbytère de l'Orient). Q. The Forsstrom collection was located; it belongs with this species, which probably is merely a small-leaved xerophytic form of *T. volubilis* L.

Tournefortia volubilis L. 382 (Mangeant).

BERBENACEAE

Lantana urticaefolia Mill. Q (as *L. camara* var. *crocea* (L.) Jacq.).

Phyla nodiflora (L.) Greene. Q.

Phyla nodiflora var. *reptans* (H.B.K.) Moldenke. 985 (l'Orient). Q.

LAMIACEAE

Leucas martinicensis (Jacq.) R. Br. Q.

* *Marsypianthes chamaedrys* (Vahl) Kuntze. 2383 (Grand Fond).

SOLANACEAE

Lycium tweedianum var. *chrysocarpum* (Urb. & Ekm.) C. L. Hitchcock. 1041 (Marigot). Q.

Solanum argillicolum Dunal. Q.

BIGNONIACEAE

* *Crescentia linearifolia* Miers. 960, 961 & 967 (morne de l'Anse a Toiny).

Distictis lactiflora (Vahl) DC. "Introduced about 1860 and escaped" Q.

ACANTHACEAE

* *Anthacanthus spinosus* (Jacq.) Nees. var. 311 (morne de Grand Fond, 250 m. alt., flanc nord), 1057 (Grand Platon, sous bois et rocailles, 150-200 m. alt. 30 Oct. 1952), 2180 (Grand Platon, terrains dacitiques 200 m., 12 Nov. 1953.) Calyx and pedicel glandular. 311 is sterile, otherwise the same as 1057 and 2180.

* *Blechum brownei* Juss. 2380 (L'Orient, Coupe-Gorge, fosses, 20 m. env.)

Justicia eustachiana Jacq. 196 & 420 (Vittet), 435 (l'Orient), 537 (Mangeant), 629 (Vittet; checked by E. C. Leonard at the U.S.N.H.), 689 (l'Orient), 1076 (morne de l'Orient), 2101 (Anse a Toiny), 2313 (Ilet Fourchu), 2337 (morne Larigot), 2351 (Vittet).

Justicia periplocifolia Jacq. Q.

RUBIACEAE

* *Borreria laevis* (Lam.) Griseb. 361 (Mangeant), 2315 (Grande Saline).

Ernodea litoraris Sw. 722 & 723 (Grand Fond), 2181 & 2209 (Grand Platon). Q.

Exostema caribaeum (Jacq.) R. & S. 185

(morne au dessus de l'Orient), 191 (Vittet), 487 (l'Orient), 501 (Vittet), 617 (morne de Petite Saline), 633 (morne au dessus de l'Orient, 704 (l'Orient). Q.

Guettarda parviflora Vahl. 269 (environs de l'Orient), 955 (bois de Seine Anglais), 613 (environs de l'Orient). Q.

Guettarda scabra (L.) Lam. 802, 821 & 822 (morne Larigot).

* *Oldenlandia callitrichoides* Griseb. 2179 (l'Orient).

* *Psychotria microdon* (DC.) Urb. 987 (prés étang de St. Jean).

Strupfia maritima Jacq. 520, 523, 736 & 795 (Cul de Sac, Grand Voute).

CAPRIFOLIACEAE

Sambucus simpsonii Rehder. "Naturalized" Q. "Cette plante peut se trouver dans l'un on l'autre enclos de Gustavia, mais n'es pas naturalisée" Le G.

CUCURBITACEAE

Cayaponia americana (Lam.) Cogn. 386 & 667 (Vittet).

Cucumis anguria L. "A l'état sauvage en quelques endroits" Le G.

Cucurbita moschata Duch. "Naturalized" Q "N'est pas naturalisé" Le G.

Momordica charantia L. 2078, 2091 & 2121 (Grand Fond; la seule localite). "Saint-Barthélemy (ex Cogniaux)" Stehlé & Quentin 3: 128.

ASTERACEAE

Ageratum conyzoides L. 378 (Vittet).

Ambrosia hispida Pursh. 570 (vieux cimetière de Public). Q.

Borrichia arborescens (L.) DC. Q.

Conyza canadensis var. *pusilla* (Nutt.) Cronq. Q.

Eclipta alba (L.) Hassk. 364 (l'Orient), 475 & 564 (St. Jean). Q.

Emilia sagittate (Vahl) DC. 2443 (chemin de Vittet). Q.

Eupatorium adoratun L. 2256 (Vittet). Q.

Lagascea mollis Cav. Q.

* *Melanthera nivea* (L.) Small. 169, 187 & 632 (l'Orient).

Pectis febrifuga H. van Hall. 942 (Chauvette), 2250 (St. Jean). Q.

Pectis humifusa Sw. 518 & 569 (Cul de Sac, pointe du Vent), 2100 (Anse Toiny). Q.

Pectis linifolia L. 362 (Mangeant). Q.

Synedrella nodiflora (L.) Gaertn. 2217 (l'Orient). Q.

Vernonia albicaulis Pers. 114 (Mangeant), 195 (l'Orient), 431 (Anse Gouverneur), 1086 (chemin de Saline a Lurin), 2017 & 2025 (chemin de Saline), 2257 (Vittet). Q.

Vernonia cinerea (L.) Less. 468 & 709 (Mangeant), 2451 (chemin de Vittet). Q.

Wedelia calycina L. C. Rich. 181 (Marigot), 363 (Mangeant), 634 (Marigot), 674 (Mangeant). Q. Forstrom.

Wedelia gracilis L. C. Rich. Q.

Wedelia parviflora L. C. Rich. Q.

Forest Preservation in the Windward Islands

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The benefits which forests confer on their owners and on the community in general are direct and indirect. Direct benefits include the timber, poles, firewood, and the minor products such as fibres, resins, and tanning materials, which the forests provide. The indirect benefits are the effects which forest areas have in conserving the oil and water supplies, and in providing shelter from wind.

The indirect benefits of forests will be dealt with first, for in the Windward Islands as elsewhere in the Caribbean, the indirect benefits are fundamentally of greater importance that the direct. Timber and other products of the forest can be imported if necessary but nothing can replace the benefits which the forest itself confers in preserving an equable climate and in conserving soil and water. There has been much controversy on the question of the effects of forests on rainfall. In some quarters it has been proved that forests have no effect on rainfall and that under certain conditions the planting of trees may even cause springs and streams to dry up. This may occur in places subject to long periods of drought where excessive transpiration in a dry atmosphere removes more moisture.

There can be no doubt, however, that the forest covered mountain ranges of the Windward Islands contribute towards the heavy rainfall which occurs in these areas. This is not due entirely to the forests themselves but to their situation. The mountain ranges, rising abruptly from the sea to heights of over 3,000 feet, cause an upthrust of the moisture laden winds from the Atlantic and rapid cooling at these elevations. This phenomenon, aided by the presence of the forest, results in heavy precipitation of rain. Even in the dry season the cooler air over the forest causes cloud formation with occasional showers at the higher altitudes. The forest cover preserves the crumbly texture of the soil, which together with the humus layer, readily absorbs and holds the water allowing it to percolate slowly to emerge later as springs and streams giving a regular flow throughout the year. It has been observed that clearing of forest in heavy rainfall areas at high altitudes causes rapid changes in the composition and structure of the soil. Organic matter in the humus layer is lost, inorganic salts are leached out, the soil becomes laterised and loses its porosity, and becomes useless for the production of agricultural crops. The loss of porosity results in a rapid runoff causing erosion, periodic flooding, and silting up of rivers, streams, and reservoirs. Such cleared lands become invaded with fern and eventually palms but it takes many years for the forest cover to be restored.

The forests are also of great benefit in breaking the force of the wind an it is only by thus preserving moist conditions that the production of cocoa, coffee, nutmegs, bananas, and other agricultural crops is possible. The apparently dry conditions which prevail along the windward coasts of Grenada, St. Vincent, St. Lucia, Dominica, and throughout the low-lying islands of the Grenadines, are not due so much to the lack of rain as to the effects of the constant winds blowing in from the sea. Annual rainfall in these areas is seldom less than 40 inches. Elsewhere in the tropics, on equally light soils, a similar rainfall supports a dense natural vegetation, whilst the vegetation on parts of the windward coast resembles the type one would expect to find with a rainfall of under 20 inches in less exposed situations. It is therefore apparent that the establishment of well-sited windbreaks would have a most beneficial effect on the productive capacity of the land either for the growing of crops or for grazing.

The larger landowners in the Windward Islands fully appreciate the indirect benefits of forest and but for their efforts in the past in protecting their forest lands, the islands would have suffered much more severely from landslides erosion, periodical flooding, and shortage of water. The danger arises when the large estates are broken up and the smaller landowners are obliged to clear more forest in order to obtain sufficient land for cultivation. The possession of land carries with it great responsibilities and it should be the aim of every landowner to leave his estate in a better condition than when he acquired it. The protection of large tracts of forest, on which the welfare of the community depends, is normally the function of the State, but in his own interests, a good landowner will protect his forests. He realizes that this is necessary and beneficial to the successful cultivation of his agricultural crops and for the maintenance of his water supplies. For example, the tops of hills and ridges should be left under forest, steep slopes should be left uncleared, and valley bottoms kept under a forest cover to prevent loss of water and pollution. Belts of forest should be retained at intervals along the contours of cultivated slopes to prevent excessive loss of soil, and to preserve moist conditions by breaking the wind. In some cases where cold drying winds sweep down valleys, belts of forest up and down the slopes will provide shelter.

In addition to the indirect benefits of forest and the importance of forest protection, it should be appreciated that although a forest may be conserved primarily for its protective functions, it can at the same time provide direct benefits in the form of timber, firewood, and minor produce. A forest is a living thing and never remains in a static condition. In a natural forest trees reach maturity, die, and fall, and their place is taken by younger trees which have previously been suppressed and have been awaiting light and space to get away. Some seeds lie dormant in the ground until an opening in the canopy affords the light and heat required for their germination. It is therefore justifiable to remove mature trees before they die, and to utilize the timber instead of leaving it to rot on the ground. A tropical rain forest is made up of a great variety of trees of all ages and often there are too many of them competing for light, moisture, and nourishment from the soil. Consequently they are not growing as vigorouly as they should and a judicious thinning out would result in more rapid growth and a higher yield. By removing the poorer kinds and utilizing them as poles or firewood the better species of timber trees would be encouraged and the condition of the forest improved.

A forest can be compared to a factory where each individual tree is a workman producing wood. Our virgin rain forest is like a factory in need of re-organization. There are too many old workmen, some already senile, who have long since ceased to produce wood. They stand in the way of advancement for the younger men below, but these also are losing their vigour as they are constantly obstructed by the old men. There are too many of them; they get in each others way and have insufficient room to work. Below them are a number of apprentices, many of whom would become good workers if given a chance. There is also among them a number of undesirable characters who try to thrust themselves forward, whose work is inferior and tends to lower the general standard of production. Finally, there are too many hangers-on, creepers, and parasites, who do no productive work themselves and sabotage the labour of the good workmen anxious to get on with the job.

A complete re-organization is necessary. First of all, the old men must be removed to make room for the more efficient younger men below. Some of these will have to go too, for they have become lazy and reduced their output through suppression and lack of incentive. They will never become efficient workmen and must give place to their more vigorous companions. Among the apprentice all the undesirables must go and every encouragement given to the strong and efficient workers.

Hangers- on cannot be tolerated and must be ruthlessly eradicated to prevent their interference with the skilled and conscientious workmen.

The process of re-organization, however, must be carefully and tactfully carried out by a manager who has studied the characteristics of his men and has a thorough knowledge of their capacities and working conditions. Certain of the old hands may have to be left in order to uphold tradition and to maintain a high quality of production. The younger men require particularly careful handling as with too drastic a reduction in their numbers they may no longer go straight; the thrusters would get in and prevent the best among the apprentice from making good. The re-organization will take time, but eventually only efficient workers will remain. Each will have room to work and the strong healthy youngsters will keep out the undesirables and finally make their way to the top.

The foregoing deals only with the rain forest type which occurs in the mountainous regions. Land in the drier areas at lower elevations should not be neglected from the forestry point of view. Most landowners in such localities have areas where, owing to the steepness of the slopes or to the poor condition of the soil, they are unable to grow agricultural crops. These lands are often covered with a dense scrub, are browsed by stock, and cut over indiscriminately for firewood. They are generally in a neglected condition but under proper management they can be improved to yield timber and fuel. One of the commonest trees of the dry zone is white cedar *(Tabebuia pallida* Miers) which is one of the most valuable trees of the Windward Islands. It regenerates profusely and cleaning of the scrub in many cases would reveal numerous seedlings. If kept free from undergrowth and creepers, these seedlings would grow into fine straight trees. The bent and gnarled condition of many white cedar trees is due to suppression and damage by undergrowth and creepers but if properly tended they would produce good clean timber. The best method of treatment is to divide the area of scrub into ten equal parts and to deal with one part each year removing all useless growth and converting what is utilizable to charcoal. Trees of timber value such as white cedar and tantacayo *(Albizzia caribbea)* may be left an espacement of about 30 x 30 feet, giving about 50 trees to the acre. Periodic cleanings will have to be made to keep the trees free of creepers and at the end of 10 years the first area treated can be cut over for firewood leaving the timber species to reach maturity. Each area is cut over successively in this manner each year. The firewood coppices on a 10-year rotation and the timber species left to reach maturity on a rotation of 50 years.

In areas where the natural growth is poor, or where it is desired to afforest open land, artificial planting is necessary. One of the most useful species for this purpose is teak *(Tectona grandis* L.) which thrives in the drier parts of these islands. It yields thinnings from the fifth year which provide useful poles; the timber is unsurpassed for strength and durability. Teak plants are raised from seed in nurseries and when 1 year old the plants are lifted and the shoot and tap root are cut back leaving a stump about 9 inches long. The stumps are pit planted at an espacement of 6 x 6 feet in the month of June.

For quick growing firewood plantations *Cassia siamea* Lamb. is recommended. The seeds of this tree are sown direct in the plantation in cultivated patches 3 feet in diameter and at an espacement of 8 x 8 feet. When the seedlings are 6 inches high they are singled out leaving one at each spot. *Cassia siamea* grown on suitable sites can produce firewood and poles on a 10-year rotation. It coppices readily and once established requires no further sowing of seed.

The accessible State forests in many of the islands are not sufficiently extensive to provide all requirements in timber, poles and firewood. Many private owners could utilize portions of their land, which are unsuited to agriculture or grazing, for the production of

timber and firewood. These woodlots would not only contribute indirectly by conserving the soil and affording shelter from wind but they would eventually yield a good cash return. The Windward Islands are entirely dependent on firewood as a source of fuel and stocks of suitable materials for burning to charcoal are becoming increasingly scarce near the large centers of consumption. Fuel is a commodity which will always be in demand and well -stocked plantations yielding 2,000 cubic feet per acre of stacked firewood in billets 3 to 6 inches in diameter should prove profitable. High quality timbers such as white cedar, teak, and mahogany, can be grown with the firewood crop and, although the trees may take over 50 years to reach maturity, it should be remembered that good stands of timber always enhance the value of the land.

Summary

The indirect benefits of forests are discussed; their effects on the climate and their importance in conserving the soil and in regulating stream flow. An allegorical description of tropical rain forest is given indicating the silvicultural treatment required to improve these forests and to increase their yield. Suggestions are made for the improvement of degraded scrub lands and landowners are advised how properly tended woodlots can benefit their lands indirectly and at the same time yield a good cash return.

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The Forestry Phase of the United States Technical Assistance Program in Chile

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The Agriculture and Natural Resources Division of the Technical Cooperation Program (Point IV) working with and through the Chilean Ministry of Agriculture, is paying particular attention to soil conservation. Foretry activities are part of this work.

The Forestry Situation
Natural Forests

Chile is about 2,500 miles long and an average of a hundred miles wide. From 18 degrees south at the Peruvian border, it stretches to 56 degrees south at Tierra del Fuego. It has climates that vary from deserts in the north to 100 inches of rainfall on the coast in the south. Elevations vary from sea level to 22,000 feet. There is a wide variety of soil types.

Most of the potentially comercial stands of timber occur in the area from 35° latitude, south, to Tierra del Fuego. The important lumbering operations are now centered in the Temuco-Puerto Montt area in the coastal mountains and on the lower slopes of the Andes. The mountainous terrain and the high rainfall —the operating season lasts about 100 days— together with a dire shortage of roads, railroads and port facilities make production costs relatively high. This, and current market and foreign exchange conditions make perhaps three-fourth of the natural timber economically inaccessible.

In 1944 a survey showed Chile to have 40 million acres, 22 percent of its land area, of forests and woodland. Fourteen million acres

were classed as commercial forest land.[1]/ The report gave the volume as 65,000 million board feet, the growth as 1.1 percent annually, and the depletion as 2 percent (1 percent by fire, 3 percent by cutting and .7 percent by other agents). Since that time the overall volume figure has changed little, but a considerable portion of the accessible timber has been out —about 3,000 million bd. ft.

For the past few years Chile has averaged an annual cut of about 250 million bd. ft. of which some 50 million have been exported.

Plantations

There are approximately 725,000 acres of tree plantations in Chile. The breakdown is about as follows: 550,000 acres of Monterey pine *(Pinus radiata* Don), 125,000 acres of blue gum *(Eucalyptus globulus* Labill.), 15,000 acres of Lombardy poplar *(Populus nigra* L. var. *italica)*, and 35,000 acres of other species.[2]/ The Monterey pine is marketed in the form of pulpwood and sawn lumber; the blue gum in the form of mine props, firewood and bridge timbers; and the Lombardy poplar is used in match manufacture and as sawn lumber.

The establishment of 550,000 acres of one single species in a period of about 20 years in a relatively small area, and with practically no market in view, is possibly without precedent. The explanations are: (1) the very high profits realized by the owners of the small plantations cut between 1900 and 1950; (2) the high-pressure salesmanship of the several investment companies that bought cheap land, planted, and sold stock or individual lots of one hectare of trees; (3) relatively low cost of land and plantation establishment; and (4) the extraordinary growth rate of Monterey pine in Chile[3]/. New Zealand has about the same acreage of Monterey pine; but, more of their plantations have been thinned and pruned, they have a market in nearby Australia and their transportation and port facilities are able to handle their production.

It is estimated that within the next 10 years, Chile will have sufficient raw material in her Monterey pine plantations to produce some 1,000 million bd. ft. of lumber annually (four times the current production of all species) and support six to eight pulp and paper mills with an annual capacity of 100,000 tons each. The recent annual production of pine has been about 25 million bd. ft. of which 8 million were exported. If Chile could triple her internal market she would still have to export about 950 million feet, which is 118 times last year's exports. Two complementary pulp and paper mills with a combined yearly capacity of 100 thousand tons are under construction but will not be in full production until 2 years from now. It would require four or five mills of this size to absorb the wood produced by the necessary thinnings and the stagnated plantations that will have to be clear cut for wood within the next 5 to 6 years.

During the last 3 years the people working with these plantations and in the forest product industries have come to recognize the problem and its magnitude. They have resolved to do everything possible to make the best of the situation under the limitations of capital and transportation facilities.

The Early Program

Efforts during the first year of the program were directed mainly to a study of the country's forestry problems with particular emphasis on tree planting and its role in soil conservation. The pine plantations and their future were obviously vital; most of the 450,000 acres established up to that time were planted on badly eroded lands that were fit

1/ In 1944 the U. S. Forest Service, in cooperation with the Chilean Development Corporation, sent a mission to Chile headed by Dr. Irvine T. Hoig to make an inventory of the forests and to evaluate the forest industries and their potentialities. The results of this excellent survey were published under the title, Forest Resources of Chile as a Basis for Industrial Expansion.

2/ See list in the Appendix.

3/ Good trees on good sites will grow to 8 inches dbh and 45 feet in height in 10 years; exceptional trees in fairly dense plantations will average an inch in diameter and 7 feet in height each year for the first 8 to 10 years. The average acre of plantation under management can be expected to produce 75 cords of pulpwood in 25 years or 48 M bd. ft. at 30 years. Higher yields can be expected on the better sites. The Hoig report (see foot note number 1) cites a 36 year old plantation with a volume of 74M bd.ft. per acre with an average annual increment of 374 cu. ft. or 2,044 bd. ft.; the report mentions another plantation with very similar yields. There are cases of claimed volumes of over 80 M bd. ft. per acre.

for nothing else. Their silvicultural management, logging, milling, and potential markets were intensively studied. There are approximately 7½ million acres of such land still to be planted to trees in Chile. Whether the existing plantations earned a profit for the investors would largely determine the future reforestation program.

During the first year the work was similar to that of a country extension forester but spread over a much larger area. Many farms were visited and recommendations made on plantations, their establishment and management, and on the management of the cutover natural stands as wood lots. Assistance was given to a government agency in an effort to trade pine lumber for hospital supplies; information was supplied to fruit growers on disease and storage problems. Bulletins were prepared on nursery procedures for the production of plants of Douglas fir *(Pseudotsuga menzesii* (Mirb. Franco) and Nepal cypres *(Cupressus torulosa* Don.) and seeds were supplied to interested landowners. This was the first assistance given in the effort to convince them of the need to plant other species. It was recommended that an experimental species-introduction project be undertaken for the following reasons:

1. The inminent supersaturation of the pine market.
2. The need for planting species that produce quality lumber with strength and durability.
3. The susceptibility of these pine plantations to insect and disease outbreaks.
4. The belief that the future of the forest industries lies mainly in plantations of exotic fast-growing species near the communication arteries and population concentrations in central Chile.

The Species Introduction Project

A species-introduction project was carried out by the cooperative "servicio" of the agricultural mission and the Ministry of Agriculture. Seed was sown in August of 1952 in the American Methodist Mission farm near Angol. They operate a fruit and ornamental nursery and offered to cooperate with the "servicio" in the project. A total 126,000 plants of 20 species were produced and were planted in 17 provinces throughout the tree zone of Chile. The plots were ½ acre in size and were in most cases planted with a 2 x 2 meter spacing on sites typical of the land available for forest planting in the area. The objective was 15 plots of each species.

The plants were produced in a newly established "servicio" nursery near the city of Chillán during the second and third years. (See Figure 1). Plants of 57 species have been produced and planted in sufficient quantities to permit a good trial of each species. Survival has been only fair due primarily to unusually adverse weather, shipping delays, and lack of protection from animals. The appendix lists the species that have been successfully established and show the most promise at the present time. At least ten of the species tried appear suitable for planting in Chile. However, if only three or four prove to be as adaptable as Monterey pine and blue gum then the project will have been a success.

Fig. 1—A view of the nursery at the end of the first season.

The Three Province Plan

It was decided by the Mission and several Ministries of the Chilean government to concentrate a large part of the technical cooperation work in the three provinces of Maule, Nuble, and Concepción, where agriculture has not kept pace with the industrial expansion of the city of Concepción. The forestry work within this area consists of the establishment of a central nursery, demonstration reforestation projects on badly-eroded lands, the introduction of new species, dune control, and extension work in planting, pruning, thinning, and management. Most of this activity is carried out as a forestry phase of the soil conservation program; some work is done in collaboration with the forestry department of the Ministry of Lands and Colonization.

It is estimated that 40 percent of the three provinces of the development area, called locally the Plan Chillán, will be classified as forest lands. The total area is 6.1 million acres with 350,000 acres already in plantations and 1.9 millions acres that should be planted. Only a small percentage of the land is covered with virgin forest or any second-growth of consequence. The area that should be planted is very badly eroded. Some of it is so bad that it is doubtful if successful plantations can be established; most of it is no good for any other use.

Plan Chillán Nursery

When it was realized that nearly one-third of the area included in the Plan needed to be reforested, the establishment of a nursery to furnish the plants was given priority. All the work of site preparation and seeding was done by hand or with animals and the first seeds were sown on September 17, 1953. The production was 3.5 million plants during the 1953-54 season and 6 million in 1954-55.

At the beginning of the third seeding season the nursery had two permanent buildings under construction. One building will serve as an office, germination room, laboratory, and refrigeration room for storage and stratification; the other will be a residence for the nursery administrator. Other buildings are being planned. A deep well has been drilled and a sprinkler irrigation system has been installed. The nursery has now been allotted 126 acres of land; the soil is being leveled and improved and interior graveled roads are under construction. Most of the tools and tractor equipment needed are on hand.

Except for the fact that there is less mechanization, the operations of this nursery are much like those in the United States. It also differs in that an unusual number of species, are produced. During the 1945-55 season, 6 million plants of 64 species were raised and sold at cost. The production goal for the 1955-56 season was increased to 12 million plants. The ultimate goal is to produce 25 million plants annually (about 17 million pine are now being planted yearly in Chile) to substitute better species for the Montery pine and to increase the acreage planted each year in the area (See Figure 2). The nursery also supplies plants to three other provinces.

Fig. 2.—A demostration of tree planting; the planting bar was introduced by ICA and is well liked by owners as well as the workers. It has doubled number of trees planted per day.

The large number and variety of species produced creates a great amount of work but is justifiable because of the research and training objectives of the project. A list of the species produced on a large scale is in the appendix.

Watershed Protection Project

The Mission is also cooperating with the Forestry Department of the Ministry of Lands and Colonization in the operation of two projects in the Plan Chillán: (1) the reforestion of the Andalien River watershed, and

(2) the stabilization of the coastal sand dunes at Chanco and Reloca. These are long range projects that will require several years and considerable money to carry them to completion. The objective is to set up demonstrational "pilot" projects, help organize them on a sound basis, train the Chileans in the proper methods by working with them until the projects are progressing normally, and then turn them over to the Forestry Department.

The Andalien river flows through the city of Concepción and often reaches flood stage in the winter. The river drains a section of the coastal range of mountains that has some of the worst erosion in Chile. Of the 175,000 acres in this watershed about one third has been planted to Monterey pine, one third is agricultural and grazing land, and the other third badly needs reforestation. The primary problem encountered in the watershed improvement program is socio-economic. Most of the land is owned in small submarginal units by farmers who, because they have insufficient land, continue to further impoverish the land and themselves by planting wheat on 20-45 percent slopes. If the reforestation and pasture establishment remedial program is to be carried out, these small farmers will need financial assistance from the government to buy cattle and live until the planted trees can be harvested.

One practical forester has worked for 8 months in a "pilot" watershed of 33,000 acres. A complete census has been taken and some 730,000 trees, sold to the farmers at cost, were planted in the area. The technician gave assistance by distributing the plants and tools and by training the planting crews on the farms.

Plans are now being made to concentrate several of the conservation projects of the Plan in the pilot area. These projects will include the construction of terraces and farm ponds, the introduction of contour farming methods, general health and sanitation improvement practices, etc. It is hoped that funds and personnel will be made available to expand this program from the pilot area to cover the whole watershed.

Chanco Sand Dune Project

There are several coastal sand dune areas in Chile where valuable agricultural land is being covered by sand dunes. An area at Chanco-Reloca is included in the Plan Chillán. Approximately 15,000 acres of some of the richest farm land in Chile have been covered by sand and an equal area is threatened. The area is almost 100 percent agricultural and once supplied a surplus of agricultural products for shipment. New hardly self-sufficient, the community will undoubtedly shrink to practically nothing if the sand dunes are not stopped.

Some excellent work was done near Chanco 50 years ago and the town was temporarily saved. Since that time, however, efforts and funds have been sporadic and part of the defense established has been lost. There are about 15,000 acres in the whole dune area of which some 1,000 are in tree plantations from 40-50 years old. This project has been in operation 15 months. The existing plantations have been improved, grazing has been practically eliminated by fencing, and about 125 acres of trees have been planted on areas protected by brush fences. A 7½-acre grass nursery has been established with accessions of European beachgrass (*Ammophila arenaria* (L.) Link) from France, Oregon, England, and Chile, and American beach grass (*A. breviligulata* Fern.) from Oregon. Small-scale experimental work is being carried out on the dunes. The nursery should produce enough grass within 2 years to begin full-scale planting for a litoral dune. The experience of the U. S. Soil Conservation Service in the Pacific Northwest has served as a guide for this project. The plans are to generally follow the accepted procedures in dune control work. It is believed, however, that experience will prove that the intermediate stage of shrubs can be eliminated and that trees can follow the grass. These sands are of volcanic origin and according to soils experts become

somewhat fertile with the addition of a small amount of organic matter. This is certainly borne out by the good growth of several species of trees on these sands. The species that are growing well on stabilized dunes at Chanco are listed in the appendix.

There is a practical forester and a practical agriculturist working on this project under the supervision of a graduate agronomist. The project will serve as a model for other dune areas in Chile.

Personnel Training

The nursery has given thorough training to two Chilean graduate agronomists[4/], four Chilean practical agronomists, and one Uruguayan practical agronomist on scholarchip to the nursery. In addition it has given same training to several people for short periods. Many groups of students of agricultural schools and universities have been conducted through the nursery.

In the Lands and Colonization projects three practical foresters and a graduate agronomist have received training in forestry, erosion control, and dune control.

Two short courses emphasizing practical work in planting, thinning, and pruning have been held to date: one for 15 foremen working in plantations and one for 25 agronomists of the Plan Chillán. As texts for the courses and to fill the needs of landowners, bulletins on species selection, planting, thinning, and pruning were prepared.

If any appreciable amount of Monterey pine lumber is to be sold in the world market it will have to come from plantations that were properly pruned and thinned in their youth. A forestry extension program is being planned to give training in plantation management to landowners and their employees. This will eventually cover all the phases of forestry normally covered by forestry extension in the United States.

In the scholarship program offered by the International Cooperation Administration, one Chilean agronomist has just recently completed a year at a forest school in the southern United States. The graduate agronomist from the nursery and the one from the Forestry Department have left for the States for a year's training in other forest schools. The men picked for these scholarships are men who have proven their worth while working in the projects.

Summary

The Point Four Forestry Program in Chile, with one American forester and an average staff of one graduate agronomist and four practical technicians, has accomplished much in the 3½ years since its inception.

1. The establishment of a permanent nursery with a potential production capacity of 25 million seedlings is almost completed. Three and one-half million plants were produced during the first year and 6 million the second. A goal of 12 million was set for the third year. This nursery carried out research on the production of seedlings of both indigenuos and exotic species under local conditions.
2. An experimental program for the introduction of new species of trees for erosion control and timber production has been undertaken. Sufficient seedlings for a good trial of 57 species have been planted in half-acre plots on sites typical of those available for tree planting.
3. A project to foment reforestation and erosion control by giving technical assistance to landowners in an important watershed has been initiated. A complete study of a pilot area was completed and, largely as a result of the project, about 600 acres of trees have been planted in the test area the first year. Plans are being made to offer many forms of agricultural assistance in the area.

4/ The term agronomist is applied to graduates in general agriculture.

4. A project for the stabilization of coastal sand dunes has been instituted. The objective is to introduce plants and the latest technology for dune control, to organize the project, and to train Chilean technicians so that they may continue the work alone.
5. Three graduate agronomists have been trained in nursery management, erosion control, general forestry and dune control. One Uruguayan practical agronomist has had a year's scholarship to the nursery and has received thorough training in nursery work. Four Chilean practical agronomists have been trained in nursery work and three practical foresters have received training in nursery work, erosion and dune control, and general forestry. Fifteen plantation managers and woods foremen and 25 graduate agronomists attended a short course on planting, pruning, and thinning which emphasized practical work.
6. One agronomist has completed a scholarship of a year's study in forestry in the United States and two more are studying there now.
7. A type of forest extension service has been offered sporadically to landowners.. Six bulletins on nursery procedures, species selection, pruning, thinning, and planting have been prepared and distributed.

Conclusions

The experience of the writer in Chile, where every species recommended at the present by foresters for large-scale planting is an exotic, has caused him to make an observation that he would like to present here. It could very well happen that after valuable time and resources have been spent developing hybrids and selecting strains of native species, that exotics will be found that will produce more and better wood than the improved indigenous species. How can we be sure trat we are working with the right trees? It seems that the approach should be to try all the species in the world that might thrive in a particular area in order to find the trees best suited for it —then begin hibridizing and selecting.

At this stage, perhaps the greatest possibilities for advancement in forestry lie in the selection of the best species for given sites. There are 1.4 million acres of Monterey pine planted in Chile, South Africa, New Zealand and Australia. In Europe exotics make up and integral part of planting and are becoming increasingly important. The variety and quantity of fruits, vegetables and meat available would be much less if the agronomists, horticulturists and animal husbandrymen had limited themselves to native species. A large experimental program with exotics is needed to find the best species for future planting in any country.

Appendix

Species other than Monterey pine, bluegum, and lombardy poplar that are planted in Chile, in order of area planted:

Pinus pinaster Aiton.
Cupressus macrocarpa Hartw.
Acacia melonoxylon R. Br.
Robinia pseudoacacia L.
Acacia dealbata Link
Eucalyptus spp.
Pinus elliottii Engelm.
Cupressus torulosa Don
C. arizonica Greene
Pseudotsuga taxifolia (Porite) Brit.

Species successfully established and doing well in the species-introduction project to date:

Catalpa speciosa Warder
Eucalyptus melliodora A. Cunn.
E. camaldulensis Dehn.
Fraxinus pennsylvanica Marsh var.*lanceolata* (Bork.) Sarg.
Gleditsia triacanthos L.
Juniperus virginiana L.
Morus alba L. var. *tartarica*
Pinus attenuata Lemm.
P. halepensis Mill.
P. jeffreyi A. Murray
P. longifolia Roxb.
P. nigra Arnold
P. taeda L.
Populus Mussolini hybrid
Ulmus pumilla L.

Species observed growing well as individuals or in small groups that show possibilities as timber trees:

Araucaria brasiliana A. Rich.
Castanea spp.
Casuarina cunninghamiana Miq.
C. equisetifolia Forst.
Cedrus deodora Loudo..
Ceratonia siliqua L.
Chamaecyparis lawsoniana Parl.
Cryptomeria japonica D. Don
Larix leptolepsis Murr.
Liquidamber styraciflua L.
Liriodendron tulipifera L.
Pinus canariensis C. Smith.
P. sabiniana Douglas
P. patula Schl. & Cham.
P. sylvestris L.
Quercus suber L.
Thuja plicata D. Don

All of these species have been tried in the species-introduction project but not enough plants were successfully field-planted to give them a fair test; some will be repeated.

Species produced on large scale in the Chillán Nursery:

Cupressus arizonica Greene
C. torulosa Don
Eucalyptus globulus Labill.
Juglans nigra L.
Pinus elliottii Engelm.
P. pinaster Aiton
P. ponderosa Douglas
P. radiata D. Don
Pseudotsuga taxifolia (Poiret) Brit. var. *viridis*
Robinia pseudoacacia L.
Sequoia sempervirens Endl.

Tree species thriving on the stabilized sand dunes at Chanco:

Acacia armata R. Br.
A. dealbata Link.
A. melanoxylon R. Br.
Cupressus macrocarpa Hartw.
C. torulosa Don
Eucalyptus globulus Labill.
Eucalyptus spp.
Pinus pinaster Aiton
P. pinea L.
P. radiata D. Don
Robinia pseudoacacia L.

Procedimientos para Pequeños Viveros Forestales en Chile[1/]

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Introducción

El presente artículo ofrece recomendaciones de tipo general sobre los procedimientos fundamentales para la crianza de plantas forestales, especialmente de coníferas. La mayoría de los pequeños viveros creados en el país a modo de experimentación puede decirse que ha fracasado y no se ha logrado de ellos el éxito económico esperado. En la actualidad sólo hay ocho a diez viveros en todo el país que producen especies exóticas, fuera del pino insigne *(Pinus radiata* D. Don), pino marítimo *(Pinus pinaster* Aiton), y el gomero azul *(Eucalyptus globulus* Labill), y que obtienen buen rendimiento económico. Las tres especies mencionadas son muy rústicas, relativamente fáciles de criar y las semillas obtenibles a bajo precio. Por el contrario otras especies con propiedades distintas como el pino Oregón *(Pseudotsuga taxifolia* (Poiret) Brit. var. *viridis)* son de difícil producción pues requieren tratamientos y equipos especiales. La semilla además de costosa, es difícil de obtener.

En la mayoría de los casos debe insistirse en la poca conveniencia de establecer viveros de tipo casero en los fundos. Un vivero requiere: buenos suelos, sistemas eficientes de regadío, inversiones considerables en equipos y materiales y además la atención permanente de un técnico con conocimientos amplios en la materia.

Los viveros fiscales y algunos particulares venden las plantas a más bajo precio que a lo que podrían ser producidas en los viveros particulares. Los pocos casos que justificarían la existencia de sus propios viveros, serían aquellos cuyos terrenos están situados en lugares inaccesibles a las vías de transporte en invierno o los que plantan una superficie mayor a unas 150 a 200 hectáreas por año.

Selección del Sitio y Programa de Fertilidad de los Suelos

En la elección del sitio más adecuado para la ubicación del vivero, es necesario considerar dos aspectos de mucha importancia: el suelo y el riego. El suelo ideal es un "migajón" arenoso, fértil, profundo y bien drenado. El pH debe fluctuar entre 5.5 y 7. Los "trumaos" no arcillosos son muy buenos. Los suelos arcillosos no se prestan. El sitio debe tener una fuente cercana de agua limpia y libre de semilla de malezas.

La creencia de que un árbol que será plantado en sitios pobres, secos o en arenales, debe ser criado en un sitio similar, es errónea; las plantas deben ser criadas en vivero de condiciones óptimas, de modo que la planta llegue al sitio definitivo con todo el vigor y fuerza posible.

Otro aspecto importante que debe ser considerado es la mano de obra, es decir, el número de obreros necesarios para una producción determinada. Una tasa que puede servir de pauta bajo las condiciones que se describen en este trabajo es de cuatro obreros para una producción de medio millón de plantas.

El sitio de ubicación debe ser de fácil acceso y más o menos a nivel. No debe estar sombreado por árboles ni rodeado por matorrales y se debe disponer de cercas adecuadas para impedir el acceso de ratones y conejos.

Programa de Fertilidad del Suelo

Al elegir un sitio, que además de reunir otras condiciones, sea fértil, seguramente no

1/ El artículo titulado "The forestry phase of the United States Technical Assistance Program in Chile" publicado en la página 28 de este misma número describe en detalle el programa forestal chileno.

se tendrá problemas serios en mantener la fertilidad. Si por el contrario, el vivero se ha establecido en un suelo agotado, erosionado o pobre es preferible cambiarlo de lugar, pues además de las pérdidas consiguientes de recursos para mejorar el suelo, difícilmente el terreno pobre podrá convertirse en terreno fértil. La mayoría de los suelos aptos para viveros en Chile, los "trumaos" u otros "migajones", son fáciles de manejar en lo que se refiere a fertilidad.

Una producción de 500 plantas forestales por metro cuadrado, que debe considerarse normal, agota los elementos del suelo mucho más que un cultivo agrícola, siendo por lo tanto mucho mayor la necesidad de emplear abonos. En este sentido debe procederse con cuidado pues el exceso de elementos químicos es más peligroso que la falta de ellos. El exceso de nitrógeno, por ejemplo, puede hacer que la planta se seque o crezca demasiado. Una manera prudente de proceder, es aplicando la misma cantidad de fertilizante que se recomienda para siembras agrícolas. Si la experiencia indica que el suelo está en un proceso avanzado de agotamiento, se puede aplicar una dosis una y media veces mayor que la recomendada. Con los años se puede ajustar las aplicaciones según se vaya teniendo experiencia. Si las plantas no se desarrollan bien por falta o exceso de elementos, es preferible consultar con un experto en suelos.

Dentro de los elementos fertilizantes, los de mayor importancia son: el nitrógeno, el fósforo y el potasio. El salitre potásico chileno es una buena fuente de nitrógeno y potasio.

Es posible que el suelo necesite cal, pero no hay que aplicarla sin establecer la necesidad, pues una aplicación excesiva puede causar deficiencias en otros elementos, además de favorecer el "damping-off". En algunas zonas de Chile, se ha exagerado el uso de cal. En todo caso, cuando no se conozca bien el suelo, es preferible hacer las consultas de rigor a un técnico.

También son importantes los elementos menores, tales como boro, cobre, manganeso, zinc, etc. En algunos suelos chilenos la falta de elementos menores presenta problemas.

La aplicación de abonos debe hacerse 2 ó 3 semanas antes de sembrar las semillas forestales. En el caso de hacerse la aplicación en la temporada de otoño, las fuertes lluvias de invierno causarían la lixiviación de los abonos con una consiguiente pérdida. Siempre existe un cierto peligro al aplicar abonos concentrados poco antes de la siembra; pero en las zonas lluviosas de Chile es necesario hacerlo. Hay que asegurarse que los abonos se mezclen muy bien con la tierra, para evitar daños a las plantas.

Es imprescindible la rotación de los suelos para evitar problemas con "damping-off", algunas especies de insectos y también para evitar, en parte, el agotamiento y cambios en la estructura del suelo. Sin embargo, y a pesar de esto, la rotación por sí sola los evita en parte pero no basta para solucionar estos problemas. Con respecto a este punto, se recomienda una rotación de 3 años; 1 año en arbolitos, 1 año en abono verde o siembra de chacarería, y el tercero en una siembra que exija un cultivo limpio, como sería porotos o maíz, lo cual tendría la ventaja de reducir la cantidad de malezas en los arbolitos al año siguiente.

Hay técnicos en suelos que dudan que los abonos verdes sean económicos y al respecto agregan que la cantidad de materia orgánica producida, no compensa el costo de producirlos. Tal vez sea más económico sembrar una especie cosechable que sembrar abono verde; en todo caso existiría materia orgánica que se incorporaría al suelo. El cultivo de arvejas y porotos es bueno pues éstos añaden nitrógeno al suelo.

La erosión laminar, común en los viveros del país, debe ser corregida por trabajos de nivelación o desagües. Todos los trabajos tendientes a mejorar los suelos resultarán perdidos, si existe erosión, aun cuando ésta sea ligera.

Tratamientos de la Semilla

En General

Las semillas forestales, al igual que las de siembras agrícolas, deben ser bien seleccionadas, frescas y de buena procedencia. Pueden ser adquiridas en semillerías comerciales, pero a menudo estas semillas están mezcladas con otras especies, no por mala intención del comerciante, sino por ignorancia de los recolectores, quienes muchas veces no saben distinguir las semillas de distintas especies. Para asegurarse de que las semillas sean frescas, sin mezcla y procedentes de buenos árboles, será preciso recolectar las semillas o comprarlas a aquellas personas que cosechan sus propias semillas. Si se trata de semillas importadas será conveniente consultar a las personas que han tenido experiencia en la importación de semillas forestales.

En la mayoría de las especies y en particular tratándose de las coníferas, las semillas pueden guardarse a una temperatura entre 1 y 5 grados centígrados y en envases herméticamente sellados hasta un período de 3 ó 4 años, sin sufrir grandemente en su capacidad germinativa. Los lotes pequeños de semillas que no justifican almacenarse pueden guardarse en frigoríficos, en frascos o "chuicos" sellados y en lugares frescos y secos, pues las semillas se deterioran rápidamente cuando están expuestas al calor y la humedad. Una manera práctica de hacerlo tratándose de lotes pequeños es sometiéndolas a una temperatura no superior a 40°C, hasta que estén bien secas, revolviéndolas constantemente; acto seguido se ponen en frascos o latas y se sellan herméticamente, colocándolas entonces en lugares frescos.

Es imprescindible conocer el porcentaje de capacidad germinativa con el objeto de calcular el número de semillas que hay que sembrar en un metro-hilera en las platabandas. Si se siembra demasiado tupido se pierde el aprovechamiento máximo de las semillas; si se siembra muy ralo, se pierde parte del costo de preparación del suelo del riego, cultivos y también, calidad en las plantas. Para producir plantas con buenas características, es preciso mantener en las platabandas densidades exactas.

La inspección física de las semillas, da una idea de lo que se puede esperar en cuanto a germinación, pero es sólo una indicación. La germinación es generalmente mucho menos que el porcentaje de semillas buenas dado por la inspección física. Para realizar la inspección física se saca una muestra representativa de todo el lote, tomando unas pocas semillas de todas las zonas de la bolsa y mezclándolas con otras muestras de otras bolsas; de esta mezcla final se sacan las semillas que serán inspeccionadas. El número de semillas que se inspecciona depende del número de kilos y de la cantidad de semillas por kilo. Se corta la semilla transversalmente, usando una hoja de afeitar, y se observa el estado del endospermo y el embrión. Si estas partes están arrugadas, amarillas, quebradas, o atacadas por insectos la semilla no germinará. Si se trata de una especie cuya semilla es pequeña, será necesario usar una lupa.

La prueba de germinación se hace 30-45 días antes de la fecha de siembra, o sea en los meses de julio y agosto. La temperatura al aire libre no es suficiente para probar la germinación y es preciso hacer las pruebas en salas o cámaras con calefacción. La temperatura debe mantenercse a 20°C en la noche y 30°C en el día. Se puede hacer pruebas en piezas con temperaturas de 22 - 23°C en el día, pero no se puede estar seguro que la prueba ha demostrado realmente la capacidad de la semilla para germinar; sin embargo una prueba bajo estas condiciones es mejor que ninguna.

Se pueden improvisar cámaras chicas con capacidades de un metro cúbico, calentadas por estufas o ampolletas eléctricas con un termómetro colocado al mismo nivel de las semillas.

Son varios los medios usados para pruebas de germinación: papel secante para pruebas pequeñas de poca importancia, y arena del río

libre de materia orgánica para pruebas de gran tamaño, son los que proponemos en el presente boletín; ambos son baratos, fáciles de conseguir y dan buenos resultados. El papel debe ser de buena calidad, mientras más grueso mejor. Las arenas que se encuentran en los ríos y que han sido bien lavadas por las aguas son buenas y no es necesario esterilizarlas, siempre que no contengan materia orgánica ni arcilla.

Las semillas se colocan uniformemente distribuídas en el medio usado a una distancia igual al diámetro de la semilla como distancia mínima. Se debe mantener el medio húmedo pero nunca sobre-saturado; si es arena, uno o dos riegos ligeros por día aplicados con una rociadora de mano es suficiente (similar a la usada para combatir insectos). El rocío debe ser muy fino para no producir movimiento de la arena en su superficie.

La germinación puede empezar entre los 5 y 10 días según sea la especie; generalmente comienza entre 10 y 12 días y termina en 30. Los lotes de semillas de la misma especie pueden variar mucho en el período pregerminativo y en el tiempo necesario para la prueba de germinación, pero generalmente 30-40 días es suficiente. Si parte de la semilla ha germinado bien a una fecha determinada y el resto no germina después de 6-8 días puede considerarse la prueba terminada.

Durante la prueba se sacan las semillas germinadas cada día o cada dos días anotando la cantidad. Se considera germinada una semilla cuando le ha salido la raíz y las hojas primarias en forma normal. A veces, a pesar de todo el cuidado, los hongos atacan las semillas antes que germinen bien; en este caso se cuenta la semilla como germinada si ha mostrado los principios de germinación en forma natural.

Tratamientos Especiales

En algunas especies es preciso tratar las semillas antes de sembrarlas para lograr una germinación rápida y más alta. Los resultados de dichos tratamientos varían en cada lote de semilla de la misma especie de tal manera que será necesario hacer pruebas de germinación con semillas tratadas y sin tratar para poder determinar si conviene hacerlo.

Los tratamientos más frecuentemente usados son:

Estratificación

El objeto de este proceso es reproducir en todas sus formas lo que le ocurre a las semillas en los bosques de climas templados. En otoño caen y están expuestas al frío; y en invierno a la humedad, hasta que comienza la época de calor en primavera, que la hace germinar. Generalmente las semillas de germinación más alta son las de coníferas, y cuando se tratan por este método su germinación es además muy uniforme y rápida. Hay especies donde la estratificación es absolutamente necesaria para conseguir una germinación satisfactoria. Una germinación alta es ventajosa y además una germinación rápida permite a las plantas un período más largo para desarrollarse. Si la germinación además de ser rápida es uniforme, las plantas tendrán el mismo tamaño y las mismas oportunidades de competir entre sí.

En el caso de que se desee saber si es o no conveniente estratificar las semillas, será necesario hacer pruebas de germinación de semillas estratificadas y sin estratificar. Estas pruebas deben comenzarse unos 100 días antes de la fecha de siembra, para dar unos 30 días para la estratificación de la muestra; 30 días para la prueba de germinación, y 40 días para efectuar la estratificación en gran escala, siempre que las pruebas hayan indicado su conveniencia.

La estratificación se hace entre 30-60 días antes de la fecha de la siembra, siendo lo más recomendable unos 45 días para la mayoría de las especies.

Aunque las semillas estratificadas germinan un poco más (4-5 por ciento) que las sin tratar, a veces es conveniente estratificar para conseguir una germinación más rápida y uniforme. La experiencia obtenida con la

especie es el criterio que se usará al tomar la decisión.

El procedimiento de estratificar las semillas es el siguiente: se toma un cajón o bandeja de lata o madera dentro del cual se coloca una capa de arena lavada de 10 cms.; se pone una cantidad suficiente de semillas en una bolsa (de género muy permeable) para formar una capa de semillas de 2 a 3 cms. de espesor; después se coloca otra capa de arena de 10 cms. sobre las semillas; se riega copiosamente la arena y semillas, debiendo el envase tener agujeros en el fondo para dejar salir el exceso de agua. Debe mantenerse muy húmedo durante el período. Una vez que se hayan preparado los envases se colocan en el frigorífico manteniéndose durante el proceso una temperatura de 3 a 4°C; si se deja subir la temperatura más allá de 6°C, se corre el riesgo de que se inicie el proceso de germinación perdiéndose con esto las semillas. Se ha tenido éxito en algunos casos estratificando semilla al aire libre y sembrando anticipadamente. Esto es muy arriesgado y no se recomienda.

Remojo

En el caso de que la estratificación sea imposible, se puede acelerar la germinación de muchas especies remojándolas en agua por períodos desde 24 horas hasta 7 ó 10 días según sea la especie (el volumen de agua ha de ser 6 a 7 veces mayor que el de las semillas). En el caso de pino Oregón el período más indicado es de 5 a 7 días. Se recomienda cambiar el agua diariamente con el objeto de impedir posibles fermentaciones. La temperatura puede fluctuar siempre que no exceda de 20°C ni sea inferior a 5°C. En casi todas las especies se puede adelantar y a veces aumentar la germinación remojando las semillas 24 horas. No se debe sobrepasar este período a menos que se tenga experiencia anterior con la especie. Conviene observar las semillas durante el remojo para asegurarse que no fermentan y además que las cáscaras no se ablanden demasiado. Las semillas mojadas son más difíciles de sembrar por lo cual se recomienda ponerlas previamente a secar 1 ó 2 horas antes de la siembra. Una vez que se ha remojado no conviene dejar secar la parte interior de la semilla.

Cocción

Las semillas de muchas especies leguminosas germinan más rápida y uniformemente si han sido hervidas desde 30 segundos hasta 5 minutos en un volumen de agua seis a siete veces al de las semillas secas. Si no se tienen datos precisos al respecto, convendrá efectuar ensayos con distintos períodos de tiempo. El agua debe estar hirviendo al sumergir las semillas las cuales se retiran rápidamente al transcurso del tiempo indicado. Una vez que las semillas han sido hervidas no conviene dejarlas secar ni tampoco esperar demasiado antes de sembrarlas.

Además de los tres tratamientos arriba citados, se emplea también la escarificación, tratamientos con ácido y tratamientos con otros productos químicos, pero su uso no se recomienda para viveros pequeños.

Cómo Calcular la Cantidad de Semilla a Regar

Generalmente el porcentaje de germinación en el vivero es de 50 a 60 por ciento de la germinación en el laboratorio; ésta depende de la preparación y del tipo de suelo, el tiempo y otros factores. Bajo condiciones favorables en buenos viveros, se puede esperar que un 30 a 60 por ciento de las semillas viables sembradas produzcan plantas aprovechables para la plantación en el campo. Este porcentaje se llama porcentaje de árboles. Las semillas que germinan en el vivero tienen que sufrir pérdidas causadas por hongos, insectos, pájaros, cultivos y además por la competencia de las otras plantas. Suponiendo que las semillas de pino germinaron un 80 por ciento en el laboratorio; la germinación en el vivero es más o menos 70 por ciento de la germinación en el laboratorio, o sea 56 por ciento de las semillas sembradas; los arbolitos aprovechables, o el porcentaje de árboles será alrededor de la mitad del

porcentaje del laboratorio 50 por ciento, o sea unas 40 plantas por cada 80 semillas viables. En las especies de hoja ancha (no coníferas), se puede estimar que el porcentaje de árboles será entre 10 y 30 por ciento del porcentaje de germinación del laboratorio.

La densidad óptima de plantas sembradas en hileras de 15 cms. de separación es 80 plantas por metro de hilera en el caso de una siembra de pino marítimo insigne o caribe. Si en el laboratorio las semillas germinaron 74 por ciento, como la germinación en el vivero se considera 70 por ciento del porcentaje anterior, la germinación en el vivero será de 52 semillas de cada 100. Ahora bien, como la cantidad deseada es de 80 plantas por metro de hilera, y sólo el 52 por ciento germinan en el vivero, resulta que es necesario sembrar 154 semillas por metro-hilera para obtener la densidad deseada que es 80. Se considera, además, que en promedio la mitad del porcentaje que germina en el laboratorio, serán plantas aprovechables; para nuestro caso son 37 plantas por cien semillas sembradas; en el caso de sembrar 154 semillas, resultarán plantas aprovechables 57, por metro de hilera. Germinan 80 por metro, pero se puede esperar la pérdida de 23 plantas por metro durante la temporada, y en la clasificación de las plantas cuando se las despacha.

Con el objeto de evitar siembras muy tupidas, o en el caso contrario, muy ralas es necesario hacer el cálculo arriba citado antes de sembrar y por cada lote de semilla.

A fines de febrero se puede calcular la producción contando muestras en todas las partes del vivero y reduciendo las cifras en un 20 por ciento por las pérdidas que suelen ocurrir desde febrero y además por aquellas plantas que serán eliminadas en la clasificación.

Labranza y Construcción de Tablones

La tierra se ara profundamente, se rastrilla y se nivela dejándola bien suelta y libre de raíces, ramitas y pastos. Si se tratara de un sitio que no hubiere tenido cultivos el año anterior, es necesario ararlo y rastrillarlo en el verano anterior a la primavera en que será sembrado, evitándose con esto una gran parte de las malezas.

Una vez que la tierra ha sido labrada y nivelada, se comienza a construir las platabandas o tablones. El ancho más conveniente y económico es de 137 cms. en la "cara del tablón" y 46 cms. las platabandas para pasillos, lo que da un total de 183 cms. por tablón. Los tablones deben dejarse a una altura media de 12 a 15 cms. sobre el fondo del pasillo para el desagüe necesario. Durante la temporada la platabanda pierde altura por la compactibilidad, reduciéndose a unos 7 ó 10 cms. sobre el fondo del pasillo. Los pasillos se pueden abrir con arado, lo que permite dejar la tierra a ambos lados y posteriormente arreglar los taludes con palas.

La Siembra

En Chile la siembra comienza el 1ro. de septiembre y termina alrededor del 15 de noviembre. Para saber la fecha más conveniente para cada especie, es preciso tener experiencia en el propio vivero con las mismas especies por 3 a 4 años. A veces el tiempo o la condición del suelo no permiten la siembra a su debido tiempo pero el atraso no se considera serio si no varía más que 10 ó 15 días de la fecha anteriormente indicada.

Inmediatamente antes de la siembra se debe remover la tierra de las platabandas y pasar un rodillo. En lo posible se aconseja que el rodillo tenga el mismo ancho del tablón (137 cms.) y que pese entre 450 y 500 kilos, debiendo tener además un diámetro de no menos de 80 cms. hasta 1 metro. En el caso de que sólo se disponga de un rodillo con la mitad del ancho y del peso del arriba descrito debe pasarse dos veces.

La tierra no debe apretarse demasiado. La compactibilidad correcta se obtiene cuando puede introducirse el dedo con facilidad 2 a 3 cms. de una sola punzada. Para lograrlo se pasa el rodillo 2 ó 3 veces según sea necesario.

Los surquitos o hileras se marcan y se abren con la ayuda de un rastrillo con clavos de maderas con puntos, que pueden ser chicos o grandes según la especie a sembrar. El rastrillo ideal para la siembra de la mayoría de las coníferas y algunas especies de hoja ancha, es aquel que tiene las siguientes características: 130 cms. de ancho con ocho clavos a una distancia de 152 mm. entre ellos, medidos de centro a centro. La profundidad de los surquitos lógicamente depende de la semilla; generalmente la profundidad debe ser sólo dos veces el diámetro de la semilla. Si las semillas son oblongas se usa el promedio de las dos medidas. En los casos de pino insigne, marítimo y caribe *(Pinus elliottii* Engelm.), la hilera se abre a una profundidad de 10-12 mms. La profundidad de la siembra es de suma importancia. En la mayoría de los casos la siembra se hace demasiado profunda. Para que las hileras resulten derechas se puede guiar el rastrillo por una cuerda de alambre. Es más práctico sembrar en hileras a lo largo del tablón en vez de atravesado. En el caso que al pasar el rastrillo se vaya acumulando tierra o basura, será necesario limpiar los clavos para evitar que la perforación sea muy ancha.

Las semillas se tapan con una mezcla de tierra y arena; la proporción depende de las características de la tierra del vivero y en cada caso tendrá que ensayarse una mezcla según el tipo de tierra. El objeto de emplear arena es para evitar la formación de una costra dura, lo que podría impedir la salida de las semillas finas. Debe evitarse usar un exceso de arena para evitar que la tierra se seque demasiado rápidamente. En chillán se usa una cuarta parte de arena y tres cuartas partes de tierra. La arena y tierra, deben pasarse por un tamiz o cedazo al mezclarse. La arena debe ser limpia y la tierra procedente de una capa situada entre 5 y 20 cms. de la superficie, para evitar que venga acompañada de semillas de malezas y esporas de hongos.

Una vez que las semillas han sido sembradas las semillas se cubren con la mezcla de tierra y arena. Este trabajo se ejecuta a mano con mucha precisión, pues las semillas sólo deben quedar cubiertas a una profundidad igual a su diámetro, una vez que haya sido pasado el rodillo. Las semillas forestales, especialmente las de coníferas, deben ser sembradas superficialmente, en ningún caso nunca más profundamente que su propio diámetro. Para lograr cierta perfección en este respecto será necesario que los tapadores realicen previamente ciertas pruebas antes de proceder a taparlas definitivamente. El trabajo de los tapadores requiere ser revisado para asegurarse que no "recargan la mano". Una siembra de coníferas bien hecha, a una profundidad correcta, siempre dejará, después del primer riego, algunas pocas semillas descubiertas lo que caracteriza a una buena siembra. Luego las semillas que hayan quedado al descubierto, se cubrirán de nuevo, sobre todo si son de mucho valor.

En relación al sistema de siembra no es recomendable regar al voleo debido a que no es posible controlar con precisión la densidad deseada de plantas. Ocurre a menudo que con este sistema, se derrocha terreno o semillas, debiéndose proceder posteriormente al raleo de plantas; en cambio, con el método de siembra en hileras se logra un cultivo mejor y más económico, al mismo tiempo que se facilite la labor de desmalezadura.

Una vez sembradas y tapadas las semillas se pasa de nuevo el rodillo sobre las platabandas.

Damping-off y la Aplicación del Acido

La enfermedad provocada por los hongos, llamada "damping-off" es común en los viveros de Chile habiéndose registrado pérdidas completas en el breve transcurso de 2 a 3 días. El primer síntoma aparece en el tallo en la forma de pequeños puntitos de agua; al cabo de un día la plantita se marchita. Esto ocurre generalmente en grupos y si además las condiciones son favorables para el desarrollo del hongo (tiempo caluroso, húmedo y sin viento) la destrucción puede abarcar grandes extensiones de plantas en pocas horas. Esta

plaga es la más temida por los técnicos de viveros.

Entre las medidas que puedan tomarse contra esta enfermedad se pueden destacar las siguientes: ubicar el vivero en un sitio ventilado pero que no lo sea en exceso; seguir una rotación tal que no se siembre en el mismo terreno 2 años seguidos; tapar las semillas con tierra y arena extraída de capas situadas a una profundidad de 30 a 50 cms. de la superficie; desinfección de la tierra con fungicidas. Todas estas medidas son eficaces y necesarias, particularmente las dos últimas, pues contribuyen además a disminuir la cantidad de malezas.

Por ser muy efectivo, barato y fácil de aplicar, se recomienda la desinfección de la tierra con ácido sulfúrico. Una vez terminada la siembra, se aplican 3 litros de una solución de 1.5 por ciento de ácido por metro cuadrado de terreno. Para preparar la solución se colocan 9 litros de agua en una regadera de 10 litros de capacidad y se añaden 200 cms. cúbicos de ácido de 66 grados (tipo comercial) revolviendo la mezcla.

En el manejo del ácido sulfúrico siempre se debe añadir ácido al agua y no agua al ácido lo cual es peligroso. Se deben tomar todas las precauciones necesarias. Los obreros que manipulen el ácido deben usar lentes protectores, guantes largos de goma, pantalones y botas de goma; en caso de accidente debe mantenerse una solución de bicabornato de sodio para lavarse, y una copita para lavarse los ojos.

Los 9 litros de la solución se aplican en 3 metros cuadrados de platabanda. Para medir el área, lo más práctico es hacerlo con un marcador que marca un tramo de 2.19 metros de la platabanda que tiene 1.37 metros de ancho y cuyo producto de exactamente 3 metros cuadrados. Al cabo de 3-4 días, si no ha llovido, se vuelve a diluir el ácido con un buen riego de regaderas.

En cualquier tratamiento o cultivo nuevo, es necesario dejar testigos no tratados, ya que ésta es la única manera de comprobar con exactitud la bondad de los tratamientos. Ya habíamos dicho anteriormente que el tratamiento con ácido no sólo sirve como ataque al damping-off, sino también a las malezas; se calcula que el efecto del ácido sobre las malezas es igual a dos desmalezaduras hechas a mano. El efecto del ácido al suelo es pequeño y de poca duración; hace bajar el pH aproximadamente un punto entre los 6 a 8 cms. de la superficie, pero esta acción desaparece luego con el riego. Con unas 10 aplicaciones de ácido se puede esperar que el pH baje permanentemente (30 años siguiendo la rotación); es de efecto beneficioso para la mayoría de los suelos de Chile a los cuales les falta un poco de acidez para ser viveros ideales de coníferas.

El ácido se puede aplicar sin perjuicio a casi todas las coníferas y muchas especies de hoja ancha. Es recomendable ensayar primero si se trata de una especie con la cual no se tiene experiencia.

Las plantitas son más susceptibles al "damping-off" durante el período de la germinación hasta un mes después. Una vez que la planta ha crecido un poco y comienza a tornarse leñosa, puede resistir el mal. Cuando el ataque ha comenzado, es difícil dominarlo; algunas veces se ha tenido éxito con Caldo Bordelés. Como modo de experimentación, se podrían probar los nuevos productos para el dominio de hongos. En el caso que se compruebe un ataque, será preciso consultar a un técnico en el ramo.

Ataques de los Pájaros, Insectos y Roedores

Durante el período de la siembra, si no se toman las debidas precauciones, los pájaros pueden causar grandes daños: el peligro no desaparece hasta que la plantita bota la cáscara de la semilla. Los pájaros escarban las semillas antes de la germinación y cortan "la cabeza" mientras la semilla germina. Este se puede evitar mezclando azarcón con las semillas antes de sembrarlas, en una cantidad suficiente para teñirlas bien. Los pájaros no

les gusta el color ni el sabor del azarcón. Si el vivero es grande este tratamiento puede resultar antieconómico. La manera más práctica para impedir el ataque de los pájaros es la de mantener algunas personas desde la salida hasta la puesta del sol para ahuyentarlos. Estas personas pueden ayudarse con tambores, escopetas, tarros y hondas. La persecución y el movimiento son preferibles al ruido. El peligro desaparece una vez que ha pasado el período de germinación.

Además de los pájaros, los ratones causan daños en los viveros, comiéndose las semillas y a veces las plantas. Lo más eficaz es combatirlos destruyendo guaridas en los matorrales, cercos vivos, zarzamoras, etc. Después puede continuarse con trampas y veneno siempre que se tomen las debidas precauciones.

El cerco de malla de alambre es la solución más adecuada contra las liebres y conejos que también atacan los viveros.

Es difícil establecer el número y clase de insectos que pueden atacar los viveros. Felizmente hoy día existen insecticidas muy efectivos, lo que hace disminuir el peligro. En el caso que los insectos estén causando pérdidas considerables lo más indicado es consultar a un entomólogo. Si no se logra encontrar fácilmente el insecto causante de las pérdidas, será preciso inspeccionar la tierra, pues hay muchos insectos en forma de larvas subterráneas que causan graves daños en los viveros. Diariamente se deben inspeccionar los tablones en busca de muestras de ataques incipientes, de tal manera que se pueda combatir la plaga antes que ésta haya alcanzado mayores proporciones.

Cultivo y Dominio de Malezas

Las malezas deben combatirse durante toda la temporada. No se debe permitir que éstas alcancen un tamaño o densidad que puedan competir con las plantitas en su desarrollo. Es conveniente que el terreno que va a ser destinado al vivero, se siembre el verano anterior con un tipo de cultivo que exija cierto grado de limpieza tales como porotos o maíz. Estos cultivos eliminan gran parte de las malezas. Las flores de las malezas alrededor del vivero, al lado de cercos y caminos deben cortarse, pues de esta manera se evita que las semillas caigan dentro del área a sembrarse. Si el agua de regadío procede de canales, debe pasarse previamente por trampas o filtros que retengan las semillas de malezas.

Al aplicar el ácido se resuelve gran parte del problema de malezas para el primer mes. El arranque de malezas debe hacerse antes que hayan crecido pues así se evita el riesgo de arrancar arbolitos. La desmalezadura debe ser hecha a mano, trabajo que desempeñan muy bien las mujeres, pues requiere manos suaves y mucha paciencia. Para destruir las malezas debe hacerse un pequeño cultivo superficial con una cultivadora de mano, trabajo que no conviene hacerlo a una profundidad mayor de 2 cms., pues se correría el riesgo de destruir las raíces de los arbolitos y al mismo tiempo se perdería demasiado humedad.

La labor de desmalezadura debe hacerse cada 2-4 semanas, según las condiciones y especies de las malezas. Es preferible efectuar este trabajo oportunamente dado que el retraso perjudicaría las plantitas.

Con respecto al dominio de las malezas con herbicidas el disolvente Stoddard es el más práctico y de mayor uso en viveros. Hay que ensayar este producto a unos pocos metros del tablón y esperar 1 ó 2 días para ver los resultados antes de ser aplicado en mayor escala. Las diferentes especies reaccionan en forma distinta y la reacción varía con las condiciones y el tiempo. El líquido puede diluirse con agua o puede aplicarse tal como viene de la refinería. La experiencia que se tiene del Vivero del Plan Chillán, indica que es más práctico aplicarlo 100 por ciento con rociadores muy finos de espaldas y con el uso del escudo. Este escudo protege las hileras de las plantas; después de la aplicación de herbicida es necesario sacar las malezas a mano en las hileras. Algunas especies de árboles no son afectadas por el disolvente y en tal caso el escudo no es necesario.

En los meses de enero y febrero las malezas disminuyen, por lo cual el intervalo de desmalezadura puede ser más largo.

Regadío

El agua de regadío debe ser de buena calidad, libre de semillas de malezas y sales tóxicas. Conviene siempre tener la fuente del agua lo más cerca posible a las platabandas, con el objeto de evitar pérdida de tiempo en la traída. Si el agua viene de canales, puede llevarse hasta las mismas platabandas y hacer pozos lo suficientemente grandes para introducir en ellos las regaderas. El uso de canoas para transportar el agua, da a veces muy buenos resultados.

El riego puede hacerse; por aspersión, infiltración y usando regaderas a mano. En los viveros con menos de 5 millones de plantas el riego por aspersión probablemente será antieconómico. En los viveros caseros se recomienda regar con regadera a mano, ó con una combinación de regadera e infiltración. Para el riego por infiltración, el terreno tiene que ser casi a nivel. Por este sistema se mantienen, los pasillos-canales entre los tablones, llenos por espacio de 1 a 2 horas, hasta que se observe que la humedad ha llegado a todo el tablón.

Durante el período de germinación no debe permitirse que el terreno se seque. A veces es necesario regar con regaderas cada 2 ó 3 días según el tiempo. El sistema por infiltración se utiliza una vez que las plantas están un poco crecidas. Las regaderas de 9 litros son las más prácticas; los agujeros deben ser finos para que el rociado de agua no dañe las plantitas ni produzca erosión en la superficie de las platabandas. Para impedir que caiga agua en exceso en un mismo punto, la persona que hace el riego debe estar caminando; se puede hacer varias pasadas ligeras hasta que la tierra esté lo suficientemente mojadas. Se puede ahorrar tiempo si cada obrero lleva dos regaderas a la vez.

Cuando las plantitas tienen 2 a 3 semanas se puede empezar a regar por infiltración; si este sistema no es suficiente, en el sentido de que no mantiene la humedad en la zona superficial, será necesario seguir regando con regaderas en combinación con el sistema de infiltración.

La frecuencia del riego depende fundamentalmente de la calidad del suelo y el estado del tiempo; generalmente se debe regar cada 8 ó 14 días durante la primera parte del verano. A fines de la temporada es necesario regar solamente lo suficiente para sostener las plantas; de esta manera se logra un mejor desarrollo de las raíces.

Durante el saque de las plantas, ha de mantenerse la tierra húmeda; en un otoño seco, será necesario regar.

Uso de la Sombra Para las Distintas Especies

Algunas especies como la *Sequoia sempervirens* (Lambert) Endl. y abetos, exigen media sombra durante los primeros 2 a 3 meses; otras la necesitan durante la primera temporada.

Si la sombra fuera necesaria se colocarán "coligues" o esteras de totoras o carrizo tejidas con cáñamo; también se pueden usar listones. No se debe proveer más que media sombra y hay que asegurarse que el material que se use para proporcionarla dé exactamente un 50 por ciento de sombra.

Es conveniente hacer ensayos con la sombra para las distintas especies. Casi todos los técnicos la recomiendan para el pino Oregón. A pesar de ello, en el Vivero de Chillán los ensayos indican que, aumentando el riego, esta especie no requiere sombra. En todo caso, cuando la sombra no sea necesaria debe suprimirse, pues su instalación es costosa y molesta.

En el caso que se desee instalarla, el material debe ser colocado, una vez terminada la germinación, a una altura de 30-35 cms. y debe quedar bien sujeto, pues con el viento puede caer y destruir las plantitas. Debe quitarse después de 2 ó 3 meses, una vez que las

plantitas hayan adquirido cierta resistencia. No se recomienda que la sombra se suprima brusca y totalmente; hay que exponer las plantitas al sol poco a poco durante 8 a 10 días para que se vayan adaptando paulatinamente.

Desarrollo de las Plantas

El desarrolo de las plantas depende de muchos factores entre los cuales se pueden enumerar los siguientes: la especie, el suelo, fecha de la siembra, la densidad de las plantas, el riego y el tiempo, etc. El único modo mediante el cual se puede llegar a conocer el grado de desarrollo que tendrá una especie determinada, es a través de la experiencia en su propio vivero. Hay especies que crecen lo suficiente en un año para ser plantadas definitivamente en el campo; este tipo de plantas se clasifica como 1-0. Esto indica que la planta quedó en la platabanda una temporada y no fué trasplantada en el vivero. Otras especies no se desarrollan suficientemente en un año y se dejan 2 años en el lugar de la siembra; ésta se clasifican como 2-0, dos años en la platabanda sin trasplantar. Algunas especies tienen que ser trasplantadas en el vivero al fin de la primera temporada para formar una planta leñosa y fomentar el desarrollo del sistema radical; éstas se clasifican como 1-1, un año en la platabanda de la siembra y uno en el vivero después del trasplante. En climas muy fríos, en algunas especies se produce la clasificación 1-1-1, o sea trasplantada dos veces.

El pino Oregón se puede producir en algunos lugares de Chile en 1 año, en otros se demora 2 años. Generalmente en las especies en las cuales no es necesario el trasplante las raíces se desarrollan bien con plantas de 2-0 (2 años en la platabanda sin trasplante).

Existe además el tratamiento de la poda de las raíces durante el verano para formar un sistema radical compacto. Esto no ha sido necesario en los viveros del DTICA[2]/, pero si una especie tiene la tendencia de formar raíces largas y escasas en vez de un sistema normal y más o menos compacto, se puede ensayar la poda de las raíces. Para observar y examinar las raíces será necesario arrancar unas pocas plantas.

La poda de las raíces se efectúa en enero o febrero. Para ello se introduce un cuchillo o machete debajo de la planta de modo que corte las raíces a 15 cms. de la superficie. Si el terreno es removido durante esta operación, deberá ser comprimido nuevamente. Para podar las raíces en gran escala se usa la hoja recomendada en el capítulo "La Extracción de los Almácigos y el Barbecho".

Para la producción de plantas con las características que se desean, es conveniente experimentar con varias densidades, con el riego, con distintas fechas de siembra y abonos. Estos experimentos previos son de alta conveniencia, pues solamente sobre la base de ellos será posible la producción de plantas de buena calidad con métodos económicos.

Calidad de las Plantas

Los factores que determinan la calidad de las plantas son: el tamaño de la planta, el desarrollo del sistema radical, el desarrollo de las ramitas u hojas secundarias, la lignificación del tallo, la existencia de yemas de invierno y la proporción entre la parte aérea y la parte subterránea. Dentro de todos estos factores, el más importante es el de la proporción entre la parte aérea y el sistema radical. Las raíces deben ser lo suficientemente desarrolladas para poder abastecer las hojas con la humedad perdida en la transpiración. La planta puede variar en tamaño dentro de ciertos límites, pero la proporción no debe variar mucho. Las raíces no deben tener un largo superior a 20 cms., si sobrepasan de este límite será preciso podarlas cuando están embalándose para el despacho. Las plantas con raíces inferiores a 12 cms. de largo no son aptas para la plantación en el campo. El hecho que una planta tenga 2 ó 3 raíces largas no basta; el sistema debe tener muchas raíces laterales.

2/ Departamento Técnico Interamericano de Cooperación Agrícola.

Entre las distintas especies, el tamaño ideal de plantas varía bastante. Una planta ideal de pino insigne y pino caribe, debe tener entre 15 y 35 cms. de altura, siendo la altura óptima, 25 cms. El diámetro en el cuello, aquel lugar en que la parte aérea se une con la parte subterránea, debe ser de 4 a 7 mm. La planta debe tener corteza, hojas secundarias (típicas del árbol maduro) y yemas de invierno.

Las plantas que han sufrido daños físicos, como raíces quebradas o raspaduras en el tallo no deben considerarse como de primera calidad y si el daño es intenso deben ser desechadas. Los arbolitos con insectos y hongos no deben ser despachados del vivero. Si la operación de eliminar esos males resulta antieconómica las plantas deben destruirse.

La clasificación de las plantas es más práctica si se hace durante el recuento en el momento de hacerse los atados. Deben ser desechadas las plantas demasiado chicas, o demasiado grandes, delgadas, aquellas con desequilibrio entre las raíces y la parte aérea, las bifurcadas, las dañadas físicamente y las que estén atacadas por enfermedades o insectos.

Generalmente se puede esperar obtener plantas de una calidad aceptable si se siguen las recomendaciones dadas pero si por efecto de condiciones especiales del clima o suelo las plantas no se desarrollan bien, habría que hacer los ensayos ya mencionados.

El Trasplante

Aquellas especies que no se desarrollan suficientemente el primer año para ser plantadas en el campo, pueden permanecer otro año en la misma platabanda si hay suficiente espacio. Estas plantas serán 2-0 (véase capítulo sobre el desarrollo de las plantas). A veces, para lograr un mayor desarrollo del sistema radical, o por exigencias del terreno, es necesario trasplantar las plantas. Esta operación puede hacerse de varias maneras: la forma más rápida y práctica, bajo las condiciones de Chile, es la de tabla de trasplante. Este sistema se usa en muchos viveros del mundo. La tabla permite una rápida y precisa colocación de las plantas en los surcos. Pequeñas cantidades se pueden trasplantar económicamente sin la tabla.

Las plantitas a ser trasplantadas se sacan y se colocan en canastos forrados con arpillera mojada. Si el tiempo es seco, las plantas deben regarse para evitar que se sequen. Es preferible hacer el trasplant een días húmedos evitando los días secos y con mucho viento.

Las plantas se llevan al galpón portátil donde se llenan las tablas. El galpón es hecho de material liviano, con techo impermeable y con los dos extremos y un lado cerrado contra el viento. El galpón no sólo protege a los obreros, sino también, evita que las plantas queden expuestas al viento.

Con el objeto de evitar pérdidas de tiempo, es necesario disponer de bastantes tablas de trasplante para que mientras algunas están siendo cargadas con plantas, otras estén siendo descargadas en el trasplante.

Para abrir el surco en línea recta, se tira una cuerda de alambre como guía de dirección, el surco lo abre un obrero con ayuda de una pala plana y cuadrada, debiendo dejar un lado del surco con pendiente y el otro lado vertical. El surco debe ser abierto lo menos posible, sólo de una amplitud suficiente para plantar los arbolitos. Una vez que el surco ha sido abierto, se coloca la tabla con las plantas, manteniendo la tabla hasta que se le haya colocado suficiente tierra sobre las raíces de las plantas para sujetarlas. Posteriormente se retira la tabla con cuidado, tratando de no arrancar las plantas; luego se llena el surco con tierra y se aprieta muy bien, pisándolas para evitar la entrada del aire, el cual podria secar las plantas. El surco debe ser un poco más profundo que el largo de las raíces, pues de no ser así, se corre el riesgo de que éstas se doblen hacia arriba, con la consiguiente probabilidad que las plantas se sequen o no se desarrollen. El cuello de la planta debe quedar exactamente en la superficie, o sea, el mismo nivel que tenían en las platabandas.

Si no existiera posibilidad de lluvia dentro de 2 ó 3 días, será preciso regar, para proporcionar humedad a las plantas, al mismo tiempo que permitir que se asiente el terreno.

La distancia en el trasplante, para la mayoría de las especies, es de 5 cms. entre las plantas y 12-15 cms. entre las hileras. Esta distancia además de dar suficiente espacio para el desarrollo de las plantas, permite un mejor aprovechamiento del terreno. Si no se desea economizar terreno, el trabajo se facilita usando una distancia de 20 a 25 cms. entre las hileras. Durante toda la operación, desde que las plantas son extraídas de los almácigos hasta llegar a plantarse, debe evitarse que las raíces se sequen pues esto reduce el porcentaje de supervivencia.

En Chile, los mejores meses para efectuar el trasplante en el vivero, son junio y julio; puede también hacerse esta operación en agosto, pero es más ventajoso hacerlo más temprano. Tampoco es recomendable muy temprano; mayo se considera como tal y entonces es probable que la mayoría de las plantas no estén en receso.

El Arranque, Barbecho y Embalaje de Plantas

Si el vivero es grande, el mejor método de arrancar es con ayuda de una hoja de acero, la cual accionada por un tractor, se hace pasar a una profundidad de 20 cms. bajo la superficie de las platabandas. La hoja debe ser de unos 25 cms. de ancho y 10 mm. de espesor; el largo de ésta debe ser del ancho de la platabanda. La hoja se conecta al sistema hidráulico del tractor, valiéndose para esto de un chasis de algún implemento agrícola. La parte anterior de la hoja se afila para cortar raíces. El tractor se coloca en el extremo de la platabanda siendo necesario picar la tierra para ubicar la hoja a la profundidad de 20 cms. Luego se pone el tractor en marcha lenta —y se baja la hoja bajo las plantas y la platabanda. Esta, además de cortar las raíces del tamaño deseado, deja suelta la tierra de la platabanda, de modo que pueden extraerse las plantas con ayuda de una horqueta, tomándolas por las hojas en grupos de 10 a 15. No se debe extraer nunca las plantas en grupos de 2 ó 3, pues pueden quebrarse las raicillas; al levantar los arbolitos en grupos de 15 a 20, se extrae con ellos la tierra, la que posteriormente se separa, dejando entero el sistema radical.

En el caso que el vivero sea chico y no se tenga tractor, el arranque de las plantas puede hacerse sólo con la pala; en tal caso conviene siempre que ésta se introduzca lo más profundo posible para extraer sin peligro las plantitas. En ningún caso las plantas deben arrancarse tirándolas de las ramas. Las raíces finas que se rompen, cuando se tiran de las plantas, son las más importantes, pues son ellas las que abastecen a la planta de humedad y elementos. Las plantas salen con mucha facilidad cuando la tierra está relativamente seca.

Una vez arrancadas se hace el recuento amarrándolas en atados de 25 a 50 plantas. Estas se clasifican durante el recuento, botando aquellas de mala calidad. Para la mayoría de las especies, los atados de 50 plantas son los más convenientes; éstos se amarran con cáñamo o pita, siempre cuidando de no dañar las plantas.

Si las plantas no van a ser despachadas inmediatamente, hay que barbecharlas en la misma platabandas o en lugar conveniente. Este se hace en surcos de 30 cms. de distancia. Al abrir el surco se deja un lado con pendiente para recibir los atados, debiendo tener además, una profundidad de 25 cms. para recibir las raíces de 20 cms. Luego se coloca una fila de atados, uno contra otro y no muy apretados; posteriormente se llena el surco con tierra y se aprieta ésta para impedir la entrada del aire. El cuello debe quedar a unos 3-5 cms. de profundidad. Si se hace el barbecho en la platabanda, se puede barbechar sobre un surco para después seguir colocando tierra y plantas. Siempre hay que dejar el espacio suficiente entre hileras o surcos para que el aire circule. Aquellas plantas cuyas ramas quedan apretadas, pueden calentarse y ser atacadas

por hongos, lo que causaría la pérdida de las plantas. Si el tiempo es seco, es preciso regar las plantas, y, si el sol y el viento son fuertes, vale la pena sombrearlas. Durante todo el tiempo que duren las operaciones de arrancar, clasificar, despachar y barbechar, no debe dejarse que las raíces se sequen. Es preferible hacer estos trabajos en tiempo húmedo y lo más rápidamente posible.

Según investigaciones recientes, se pueden dejar las plantas de coníferas en un barbecho bien hecho, hasta cuatro semanas, sin que por esto baje el porcentaje de supervivencia en la plantación. Este hecho permite al vivero estar siempre adelantado en la preparación de plantas para el embalaje, al mismo tiempo que permite mantener existencias para entrega inmediata.

Todas las plantas de especies de hojas caducas pueden ser extraídas, luego que las hojas han caído,[3]/ en una operación, y barbechadas aún cuando no sean despachadas dentro de 2 ó 3 meses. Estas plantas están en un receso casi completo y no sufren con períodos largos en el barbecho. Mientras las plantas están en barbecho, si no llueve, hay que regarlas para mantener el suelo húmedo.

Si el vivero es chico produce plantas para el uso del mismo fundo, entonces el embalaje no es un problema. Para tal efecto, las plantas se llevan simplemente al lugar donde serán plantadas en canastos o cajones forrados con arpilleras, y se mantienen mojadas, rociándolas con agua. Si hay que transportar plantas a distancias muy largas, de más de un día de viaje, será necesario embalarlas muy bien para que lleguen al sitio de destino en buenas condiciones. En el caso que el viaje sea de 1 ó 2 días y si el vehículo lo permitiera, las plantas pueden barbecharse directamente en la camioneta o camión, sin necesidad de embalarlas. Para el barbecho se usa en este caso, aserrín o tierra mojada. Si hay una gran cantidad de plantas se pueden construir varios pisos en el vehículo. Durante el viaje, será necesario proteger las plantas contra el viento con una carpa. Si el vehículo se detiene en el trayecto por más de una hora, será necesario levantar la carpa para permitir la ventilación de las plantas.

Los cajones ventilados son los mejores envases para transportar plantas forestales. En su lugar se puede usar canastos, lo cual resulta más económico. Para proceder a embalar las plantas se hace lo siguiente: se coloca una capa de 8 a 10 cms. de tierra mojada, viruta o aserrín, en el fondo del cajón y se pone los atados de las plantas parados con un poco de aserrín entre ellos. Se tapa el cajón con listones, lo cual permite la entrada del aire. También se coloca una capa mojada de tierra en el fondo del canasto; posteriormente se recuestan las plantas con las ramas hacia afuera y las raíces hacia adentro. De este modo las copas reciben el aire que pasa por el costado del canasto, y las raíces se juntan en el centro de éste. Mientras se van poniendo las plantas, se añade a las raíces aserrín[4]/ o tierra mojada; finalmente se tapa el canasto con arpillera o con una tapa de mimbre. Antes de despachar las plantas se mojan las raíces sumergiendo los cajones en el agua, hasta el nivel del cuello de las plantas. No conviene sumergir los canastos, si las plantas están acostadas; se debe rociarlas mientras que se llena el canasto.

No es conveniente dejar las plantas más tiempo que el necesario en los envases que se usan para el traslado. Mientras más permanezcan en ellos, tanto más bajo será el predimiento en el campo. Las plantas se podrán dejar en los envases, como máximo 5 ó 6 días, sin reducir sus posibilidades de supervivencia. Tan pronto llegan las plantas al lugar donde serán plantadas se abrirán los envases procediendo al mismo tiempo a barbechar las plantas que no serán plantadas el mismo día. Aquellas plantas que llegan calientes, atacadas por hongos, fermentadas o secas, no son aptas para plantarse.

3/ En climas temolados las especies de hojas caducos pierden las hojas al aproximarse el invierno.

4/ NOTA DEL EDITOR. El musgo de pantano se presto también para dicho propósito. Absorbe y retiene gran cantidad de agua, es sumamente liviano y no ensucia como lo tierra.

Administración del Vivero

Mirado desde el punto de vista económico, el vivero constituye una inversión la cual está destinada a generar ingresos, aún cuando las plantas no sean vendidas. En la primera parte de este artículo se destaca la conveniencia de comprar las plantas en lugar de producirlas, siempre que se trate de cantidades moderadas. El vivero, como cualquier otra actividad comercial, debe ser bien administrado, debiéndose llevar un buen sistema de contabilidad que permita la contabilización e inventarios del equipo, terreno y gastos, etc. Solamente con un buen sistema de control de ingresos y gastos, se podrá saber el verdadero costo de las plantas y además la conveniencia de seguirlas produciendo.

El encargado del vivero debe poseer mucha experiencia para resolver los problemas técnicos o en su defecto estar entrenado en el manejo de viveros. Entre sus funciones rutinarias deberá llevar una verdadera hoja de vida de cada especie, con todos los datos concernientes a su germinación, desarrollo y observaciones especiales que se estimen de interés; deberá confeccionar un plano que indique el uso que se hará del suelo cada año. También será conveniente un cuadro, que proporcione los datos completos sobre cada especie sembrada y un cuadro de riego que permita ver el efecto del agua sobre el desarrollo de las plantas.

Finalmente, deberá imperar en todo momento el buen sentido y el técnico o encargado debe estar al tanto con los adelantos de su especialidad ya sea en forma particular o a través de consultas con otros técnicos. En esta forma se puede esperar que los viveros forestales tengan el éxito que de ellos se espera.

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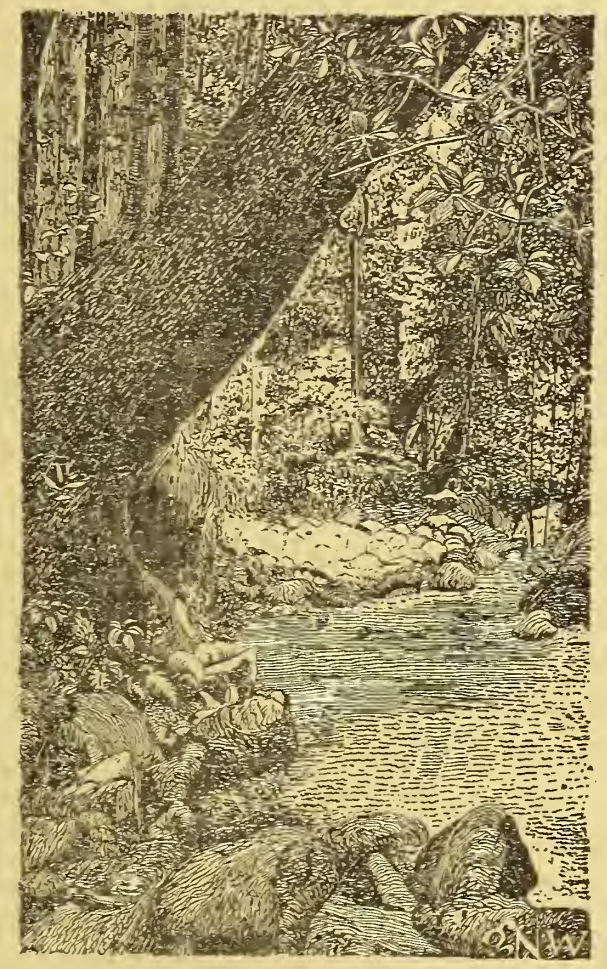

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Caribbean Forester

El "Caribbean Forester", revista que el Servicio Forestal del Departamento de Agricultura de los Estados Unidos comenzó a publicarse en julio de 1938 se distribuye semestralmente sin costo alguno y está dedicada a encauzar la mejor ordenación de los recursos forestales de la región del Caribe. Su propósito es estrechar las relaciones que existen entre los científicos interesados en la Ciencia Forestal y ciencias afines encarándoles con los problemas confrontados, las políticas forestales vigentes y el trabajo que se viene haciendo para lograr ese objetivo técnico

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The "Caribbean Forester", published since July 1938 by the Forest Service, U. S. Department of Agriculture, is a free semiannual journal devoted to the encouragement of improved management of the forest resources of the Caribbean region by keeping students of forestry and allied sciences in touch with the specific problems faced, the policies in effect, and the work being done toward this end throughout the region.

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Le "Caribbean Forester", qui a été publié depuis Juliet 1938 par le Service Forestier du Département de l'Agriculture des Etats-Unis, est une revue semestriele gratuite, dediée a encourager l'aménagement rationnel des forêts de la region caraibe. Son but est d'entretenir des relations scientifiques entre ceux qui s'interéssent aux Sciences Forestières, ses problemès et ses méthodes les plus récentes, ainsi qu'aux travaux effectués pour réaliser cet objectif d'amelioration technique.

On accept voluntiers des contribution ne dépassant pas 20 pages dactilographiées. Elles doivent être écrites dans la langue maternelle de l'auteur qui voudra bien préciser son titre ou sa position professionnelle et en les accompagnant d'un résumé de l'étude. Les articles doivent être addressés au Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

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L. R. Holdridge and *Gerardo Budowski*, Costa Rica.

Sistemas de Regeneración de los Bosques de Bajura en la América Tropical

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INTRODUCCION

Una de las ramas más importantes de la silvicultura tropical es sin duda la regeneración de los bosques mixtos.

Es bien sabido que el actual sistema de explotación que se usa en los bosques de casi todos los países de la América Latina es realmente una selección negativa de las especies valiosas. Solamente se explotan unos pocos árboles dejando multitud de otras especies no comerciables las que encuentran así una oportunidad para desarrollarse mejor. Si a ésto se suman los daños causados por los incendios periódicos, el pastoreo irracional la agricultura nómada así como la ausencia casi general de métodos apropiados para asegurar la regeneración de los bosques, no resulta difícil comprender el por qué la economía y el bienestar forestal de muchas zonas está sufriendo las consecuencias desastrosas de tal situación. Países como Cuba, El Salvador y Puerto Rico, otrora cubiertos de bosques, como consecuencia de su falta de previsión tienen que importar prácticamente todas sus existencias en maderas y otros productos derivados de los árboles. Además sufren los correspondientes efectos perjudiciales sobre el régimen de las aguas, la ausencia de la fauna silvestre y la falta de zonas de esparcimiento para sus poblaciones urbanas. La misma situación existe en otros países, los que si bien poseen todavía bosques en zonas remotas sufren de la misma escasez de zonas forestales en lugares poblados y acequibles. Aún en las mismas zonas rurales es frecuente pagar altos precios por maderas de construcción, leña, postes de cerca y otros productos similares que otrora podían conseguirse con relativa facilidad.

No debe creerse sin embargo que los gobiernos han permanecido indiferentes frente a tal situación. Existen leyes, "magníficas" según muchos oficiales, pero completamente inoperantes en la práctica. Ni siquiera los cambios continuos en las leyes o la aplicación rígida de sus cláusulas han podido frenar apreciablemente tal estado de las cosas. Así mismo se han iniciado a menudo enormes "programas de reforestación" generalmente mediante la distribución gratuita de arbolitos, una política que desgraciadamente todavía goza de mucha popularidad. Beard (*23*, p. *18*)[1/] muy acertadamente comenta al respecto: "La dasonomía tropical en casi cada país donde ha sido practicada sufrió en su infancia de una enfermedad que pudiera llamarse el furor de las plantaciones, una idea fija que era necesario establecer plantaciones a toda velocidad y en todas partes, a menudo sin ninguna investigación previa. Después de desperdiciar mucho dinero el programa ha tenido que sufrir una revisión a favor de métodos más naturales, basados en experimentos más cuidadosos."

La historia está llena de tales fracasos (*47*) y aunque algunos han sido publicados (*69*, *30*) otros, la gran mayoría, nunca han sido informados. Pero no resulta difícil revisar los informes anuales de los servicios forestales o ministerios de agricultura de muchos países con las cifras de arbolitos distribuídos y luego constatar en el campo que todo ha sido un fracaso. Así lo encontró por ejemplo el actual Servicio Forestal de Guatemala al investigar la suerte de millones de arbolitos distribuídos en los últimos años. El resultado ha sido francamente desalentador.

1/ Los números en bastardillas entre paréntesis se refieren a la Referencias Citadas en la página 70

Cierto es que resulta más fácil criticar que sugerir soluciones definitivas. Antes de pensar en la reforestación o regeneración de bosques, debemos controlar los incendios forestales y el libre pasatoreo del ganado. Pero aún dado el caso hipotético de haber resuelto satisfactoriamente dichas condiciones previas, surgen preguntas en relación a la reforestación. ¿Qué especies usar? ¿Cómo plantarlas y en qué fecha? ¿Qué cuidados debe darse a las plantaciones? ¿Podría conseguirse regeneración natural si el bosque se somete a tratamientos adecuados?; y finalmente y de mayor importancia que todas las anteriores ¿cómo lograr nuestro objetivo con el mínimo de gastos y el máximo de eficiencia?

La contestación a estas preguntas ha sido el objeto de este estudio. A tal efecto se ha hecho un análisis de aquellas experiencias que hasta la fecha pueden considerarse aciertos, especialmente si estos fueron éxitos económicos. La enseñanza de otros países tropicales aún cuando no americanos, será igualmente valiosa ya que se ha publicado poco en la América Latina en artículos realmente científicos; casi siempre las publicaciones son de tipo divulgable y popular lo que si bien no les resta mérito, pues también esta literatura es valiosa, sin embargo no ayuda mucho a ampliar nuestros conocimientos. Tales publicaciones, a menudo están relacionadas con proyectos de reforestación basados sobre poca experimentación o sobre una práctica muy limitada.

Suelos Forestales

Ante cualquier problema de reforestación o regeneración es preciso examinar cuidadosamente el aspecto de suelos. Es importante recordar que casi siempre resulta más fácil reforestar un suelo forestal que un suelo degradado de sabana. El suelo de sabana es generalmente más compacto, a menudo de drenaje deficiente o excesivo y en general ofrece problemas especiales. Muchas veces por lo tanto, cuando hay que reforestar terrenos que han sido arruinados por los incendios repetidos, la agricultura y el pastoreo irracional, es ilusorio pensar en establecer plantaciones de especies valiosas a menos que sea con costos elevadísimos (irrigación, abono, preparación de hoyos profundos, etc.) Si lo que se persigue es la reforestación de una cuenca hidrográfica, lo mejor es proteger la zona y esperar el proceso natural de reforestación si es que existen bosques cercanos proveedores de semillas. Si acaso se intenta acelerar este proceso, conviene usar plantas invasoras y muy rústicas y acaso también ayudar a los brinzales que se establecen a librarse de la competencia de las hierbas (*52, 29*).

En todo caso, es un proceso largo y laborioso y sin duda antieconómico cuando se intenta producir árboles maderables. Regenerar un bosque, aunque esté degradado resulta mucho más fácil y con buenas posibilidades económicas que establecer plantaciones forestales artificialmente.

SISTEMAS SILVICULTURALES DE REGENERACION MAS USADOS

Como regla general, los bosques tropicales son más bien pobres en maderas valiosas, bien sean vírgenes o degradados. Esto se debe naturalmente a su composición heterogénea con solamente pocas especies comerciables, resultando en altos costos de explotación. Por lo tanto una alteración del bosque, particularmente en su estructura y composición son esenciales a fin de elevar la proporción de especies comerciables (41). Es lo que Dawkins (37) llama "refinamiento' del bosque para dar énfasis a la idea de convertir el rodal en un producto de mayor valor. Pero tales refinamientos según Marshall (63) deben hacerse con debido respeto a las condiciones ecológicas de manera que el nuevo rodal a crearse pueda mantenerse permanentemente.

Actualmente se usan corrientemente tres sistemas de regeneración de bosques (*38*):

1. Si el bosque es de escaso valor comercial, se practica el corte a matarrasa seguido por la reforestación de una (o raras veces más especies) de mayor valor y de edad más uniforme. Esto se logra

mediante plantación e induciendo la regeneración deseada.

2. La introducción de especies más valiosas para enriquecer el rodal. En este método generalmente se abren líneas o franjas de ancho y espaciamiento variables a través del bosque, plantando o sembrando las especies deseadas.
3. El sistema generalmente conocido por el término inglés de "shelterwood" en el cual se estimula la regeneración natural bajo un dosel protector y proveedor de semillas mediante la apertura gradual del rodal hasta eliminar todo el dosel. La luz se regula para asegurar la mejor germinación y el desarrollo de una nueva generación más valiosa. En la terminología española se designa como "cortas uniformes o cortas progresivas y aclareos sucesivos" (44) o "regeneración bajo cubierta protectora de pies de masa reservados, previa una corta a hecho o rasa, y otra ulterior" (48). En el presente estudio se ha adoptado el término: "regeneración bajo dosel protector".

Cada uno de los tres sistemas tiene su justificación, sus ventajas y desventajas y conviene evaluar todos los factores antes de decidirse por alguno; aún existe la posibilidad de hacer combinaciones (1; 43; 71).

Regeneración por Medio del Corte a Matarrasa

Es interesante constatar que dicho sistema no recibe la aprobación de un gran número de dasónomos que lo estiman peligroso y demasiado drástico. Si bien es cierto que se tropieza con peligros y se elimina de una vez el bosque con todas sus influencias favorables no puede negarse sin embargo, que bajo ciertas condiciones, este método se ha acreditado rotundos éxitos, como podrá comprobarse por las experiencias que luego se describen.

Si un terreno acabado de deforestar se deja a si mismo sin otras intervenciones regresa a la fase forestal aunque la primera vegetación arbórea que sucede a los bejucos y las hierbas se parece poco al bosque original (11, 13) Ciertas especies "invasoras" son de muy rápido crecimiento; su semilla es ligera, abundante y fácilmente propagada por el viento. Ejemplos bien conocidos en la América tropical son *Cecropia* spp. *Ochroma lagopus* Sw., *Trema micrantha* (L.) Blume, *Heliocarpus* sp., etc.

La madera de tales especies es liviana y se deteriora rápidamente después de cortado el árbol. Sin embargo no persisten por mucho tiempo y son sucedidas por otras especies que germinan y se desarrollan bajo su sombra. Se puede asumir que finalmente el bosque vuelve más o menos a su forma original (*45*, *58*).

Si el suelo es cultivado durante varios años, después de desaparecido el bosque una vegetación de tipo herbáceo tiende a ocupar el lugar, la que resulta luego muy difícil de eradicar. Además el suelo se deteriora rápidamente puesto que al perder su cubierta protectora queda expuesto a la acción de las lluvias y de la intensa radiación solar que tiende a acelerar su rápida degradación (*26*). Esta degradación se traduce más que en pérdida de materia orgánica y de nutrientes en la compactación del suelo y en la formación de capas impermeables a veces ferruginosas, todo lo cual dificulta el drenaje, sobre todo en zonas llanas. Si a ésto se agregan los incendios periódicos que siguen extendiendo la superficie de la sábana artificial así creada, es fácil comprender el por qué de las extensas llanuras estériles en lugares donde antes existían bosques frondosos.

Todo ésto conduce a la conclusión de que la reforestación de un bosque cortado a matarrasa tiene que hacerse muy rápidamente. De ahí una de las ventajas de usar arbolitos seleccionados del vivero para las plantaciones a fin de utilizar las plantas más aptas para competir con la vegetación herbácea y otras plantas.

El Sistema "Taungya"

Con el método de corta a matarrasa, los éxitos más espectaculares han sido logrados

con este sistema, originado en la India. Es muy corriente en Asia, Africa y aparentemente ha tenido éxito en Trinidad y en la Hondura Británica. Esencialmente se permite el uso por un tiempo limitado del terreno recién deforestado para fincas agrícolas, pero al abandonarlo se cuida que quede plantado con especies maderables de valor. Generalmente se plantan los arbolitos cuando empiezan las lluvias. Cuando se limpian los cultivos también se limpian los arbolitos plantados. Terminada la cosecha y al abandonarse el terreno uno o pocos años después, éste queda pues reforestado. Esto no quiere decir que quedará abandonado porque luego se realizan diversas operaciones silviculturales como limpiezas, raleos, etc. En esta forma, la plantación se inicia con muy pocos gastos y hasta pueden haber algunas ganancias iniciales si puede aprovecharse el monte tumbado y conseguirse buenas cosechas agrícolas, compensando así los gastos de semilleros, viveros y plantaciones. En Trinidad en los terrenos del gobierno, se logra el máximo aprovechamiento del monte explotando primero los árboles de valor para madera o postes y otorgando luego concesiones favorables a los carboneros pero exigiéndoles que corten todos los árboles remanentes. Terminada la labor de los carboneros, se habilita el terreno a los agricultores de la región, los que pueden dedicarse a determinados cultivos bajo la condición de plantar y cuidar brinzales especialmente preparados (con tallo y raíz recortados) de teca (*Tectona grandis* L.), suministrados por el Servicio Forestal. Al cabo de 2 años los agricultores repiten la misma operación en otra región. Hasta la fecha se han "convertido" unas 3.500 hectáreas mediante este plan (*8, 31*).

La misma operación ha tenido buena acogida en el Congo Belga donde existe buena demanda de leña para los barcos ribereños y se cultiva el banano por unos pocos años; las especies establecidas son otras, aunque al igual que la teca, son esencialmente de rápido crecimiento e intolerantes o sea que necesitan mucha luz y no toleran la sombra. Otros países informan experiencias similares tales como en Hondura Británica, que establece plantaciones de pino *(Pinus caribaea Morelet)* a costa de bosques de hoja ancha (*7, 64*); La India (*2, 56*); Australia tropical (*9*); Bengala del Oeste (*6*); La Isla de Nueva Bretaña en el Pacífico tropical con *Eucalyptus deglupta* Blume (*49*) y numerosos países africanos (*3*)y del trópico en general.

Como puede verse entre las características del sistema figuran el empleo de especies valiosas de rápido crecimiento y amantes de luz la mejor utilización del bosque que ha de eliminarse, el cultivo temporal del suelo y la plantación de especies valiosas. Cuando alguno o varios de estos factores no se encuentran presentes, el sistema puede llegar a ser antieconómico o completamente inaplicable. Al no haber suficiente demanda por tierras de cultivo o cuando la población no está acostumbrada al sistema rotativo de agricultura o si no pueden controlarse todos los procesos, el sistema ha tropezado con inconvenientes (*4, 61*).

Otras Experiencias

En Honduras, Guatemala y otros países centroamericanos, la United Fruit Company y otros propietarios privados han establecido algunas plantaciones especialmente con teca (*Tectona grandis* L.), caoba (*Swietenia macrophylla* King), primavera *(Cybistax donnell-smithii* (Rose) Seibert) y *Eucalyptus deglupta* Blume. Hubo grandes inversiones iniciales porque aparentemente no se utilizó mayormente ni la madera ni el suelo para agricultura; sin embargo parece que el alto precio de la madera que habrá de cosecharse será compensación más que suficiente por las inversiones hechas. Aparentemente ésto vale también para otros sitios donde plantaciones similares se han logrado satisfactoriamente tales como las de caoba en las Filipinas (*34*) y en Martinica (*33*) y okoume (*Aucoumea klaineana* Pierre) en Africa (*16*). Algunas experiencias con el género *Eucalyptus* han tenido

particular éxito tanto en las zonas altas como en las zonas bajas calientes (*12*). En Cuba una compañía minera ha iniciado plantaciones con *Eucalyptus saligna* Sm., bajo la dirección de un selvicultor graduado, que prometen alcanzar mucho más éxito del que se había pensado al principio. El bosque original estaba muy degradado y prácticamente sin valor comercial. Las últimas plantaciones de esta zona sin embargo se están efectuando en terrenos de sabana y aparentemente con el mismo éxito. La medida fué iniciada más que todo por el afán de la compañía de demostrar su buena fé ya que utilizaban grandes cantidades de madera de pino (*Pinus tropicalis)* para las bocaminas. Ahora sin embargo, todo parece indicar que la plantación es también un éxito económico. El crecimiento es realmente asombroso a tal punto que algunos de los mejores ejemplares miden 90 pies (27 metros) de altura con un diámetro de altura del pecho de 14 pulgadas (36 cms.) después de escasamente 5 años. Las condiciones ecológicas corresponden al bosque tropical seco de la clasificación de Holdridge(*51*), teniendo una temperatura media anual de aproximadamente 25°C y una precipitación media anual de unos 1.600 mm. Algunos de los árboles ya están prestando su servicio en la mina después de haber sido previamente tratados con preservativos que los harán más inmunes contra la podredumbre y los insectos. Otros árboles han sido cortados hace 1 año para prestar su servicio como postes telegráficos cerca de la Habana y también fueron tratados con preservativos.

Muchas otras especies han sido investigadas en cuanto a su habilidad para ser reproducidas en condiciones similares (*63, 27, 3*).

Ventajas e Inconvenientes del Corte a Matarrasa como Método de Regeneración

Entre las desventajas más notables que han sido denunciadas para este método se menciona en primer plano el radical cambio ecológico. El suelo queda espuesto y a falta de cubierta protectora, puede degradarse muy rápidamente. Es por ello que no conviene en ningún caso dejar el terreno descubierto por mucho tiempo. Los terrenos arenosos especialmente se lavan con suma facilidad, mientras que los terrenos arcillosos tienen tendencia a compactarse y a endurecerse, causando dificultades de drenaje. Una corta exposición del suelo sin embargo, no tiene mayores consecuencias. Se comprende así por qué mucho edafólogos tropicales defienden los llamados "sistemas primitivos" de agricultura que consiste en rotar el terreno que ha de cultivarse a expensas de los bosques. Al dejar que los retoños y las malezas cubran rápidamente el terreno cultivado, su protección queda asegurada.

Por otra parte, en vista de que muchos de los éxitos alcanzados se han logrado con especies exóticas y en plantaciones puras, se corre el peligro de enfermedades y plagas (*73, 59*). Sin embargo parece que hasta la fecha la teca y las diferentes especies de *Eucalyptus* no han sido afectadas. Con otras especies sin embargo, el resultado no ha sido tan favorable. En las plantaciones de okoume (*Aucoumea klaineana Pierre*) en Africa se informa el ataque de un hongo (*Pestallozia*) y de insectos (*15*) y entre las Meliaceae el taladrador *Hypsipyla grandella* ha causado extensos daños (*50, 63*). En vista de ello se ha pensado en utilizar un espaciamiento muy amplio en el sistema taungya, con el propósito de crear un bosque mixto donde se desarrollarán muchas especies además de las plantadas (*54*). Esto parece muy satisfactorio y sin duda más económico que el intento de mantener toda la plantación rigurosamente pura y sin adición de otras especies invasoras lo que resulta muy costoso como por ejemplo en las plantaciones de la United Fruit Company en la América Central. Además se puede conseguir buena forma del tronco mediante la sombra lateral que proyectan las otras especies dentro de la plantación y finalmente cabe pensar que de todas maneras, cuando las plantaciones se hacen densas, tarde o temprano el número de árboles cosechables tendrá que disminuir con los raleos.

La idea de establecer plantaciones mixtas usando dos o más especies, ha sido a menudo defendida por técnicos y profanos en la materia, pero se carece de suficientes experiencias al respecto. En Cuba, se ha reforestado una área pequeña usando teca, majagua (*Hibiscus tiliaceus* L.) y caoba (*Swietenia mahagoni Jacq.*) Al cabo de varios años algunos ejemplares de teca y majagua se conservaban en buenas condiciones mientras que la caoba, de crecimiento más lento, estaba en vías de quedar completamente suprimida.

El control de las prácticas agrícolas locales y el cuidado necesario a las plantaciones recién establecidas resulta otro factor de importancia. En Trinidad solamente se permiten ciertos cultivos y por un tiempo rigurosamente estipulado, los agricultores deben suscribir un contrato regular y se toman muchas otras precauciones(*31*). La tenencia de la tierra parece un factor fundamental para aplicar exitosamente el sistema taungya y solamente el rígido control del gobierno en Trinidad puede asegurar el éxito en los terrenos nacionales. En otros países ya existe un complicado problema de tenencia de la tierra por los llamados "conuqueros", "parásitos", "precaristas", etc. El nombre cambia en los diferentes países pero los agricultores designados así son esencialmente los mismos. Practican agricultura nómada en tierras que nominalmente no son de ellos aunque frecuentemente las hayan ocupado desde hace mucho tiempo, y en algunos países son protegidos por diferentes leyes. No es fácil predecir cuál sería la acogida y las consecuencias que pueden resultar al aplicarse el sistema taungya. El desplazamiento de agricultores siempre ha demostrado ser un problema delicado puesto que intervienen factores económicos, sociales y políticos. Sinembargo ésto no quiere decir que el sistema está destinado a fracasar. Al contrario, la organización de comunidades agrícola-forestales o cooperativas con un plan de trabajo a largo plazo, técnicamente elaborado, quizás pueda llegar a ser una solución muy satisfactoria para reagrupar estos agricultores errantes. El sistema taungya acaso sirva de instrumento para lograr este tan deseado objetivo.

Un factor definitivamente limitante en este método resulta ser la elección de las especies. Es evidente que solamente pueden cultivarse especies de rápido crecimiento que puedan competir satisfactoriamente con otros invasores; también deben ser muy intolerantes o sea ávidas de luz y naturalmente, valiosas. Nunca debe permitirse la supresión por parte de la vegetación natural que también invade los claros; la característica de las especies escogidas debe ser tal que los costos de limpieza sean mantenidos al mínimo.

Cuidado de la Regeneración Natural Después del Corte a Matarrasa

A medida que nuestros conocimientos silviculturales adelanten, resulta cada vez más evidente que los "invasores" naturales que se establecen después de cortar el bosque original no han recibido hasta la fecha la atención que merecen. Esta situación está cambiando rápidamente con la aparición de nuevos mercados para maderas blandas y de corta duración natural. Un ejemplo típico puede encontrarse en la balsa (*Ochroma lagopus* Sw.) anteriormente considerada sin valor en casi todos los países pero hoy más apreciada. Así mismo, en el Perú, ocurren cada año extensos desmontes naturales producidos por los cambios en el curso de los ríos durante el apogeo de las lluvias. Numerosas especies de cetico (*Cecropia* spp.) se establecen inmediatamente sobre los terrenos abandonados —y fertilizados— cuando el agua recede. Hoy tales rodales se consideran como muy buena fuente de pulpa para papel ya que pueden cosecharse después de solamente 4 años (*75*). El género está abundantemente representado en otros países del trópico americano donde generalmente se llama guarumo, yagrumo, embaúba, etc. Todos sus representantes son agresivos, intolerantes y de rapidísimo crecimiento invadiendo claros o desmontes.

En Puerto Rico el roble (*Tabebuia pallida* Miers) de valiosa madera, puede establecerse

sobre suelos pobres degradados, aún cuando ya exista una cubierta herbácea, algo notable y sin duda un factor limitante para muchas otras especies. El manejo de esta especie establecida naturalmente es muy prometedor (*76.*)

Finalmente en Costa Rica y otros países centroamericanos, un árbol de madera muy valiosa, el laurel (*Cordia alliodora* R. & P. (Cham) se establece rápidamente sobre terrenos deforestados que han sido pastoreados. En la actualidad muchos propietarios comprenden perfectamente el valor que representa este valioso "invasor" y, cuando limpian el pasto de arbustos y otras mayas yerbas, tienen cuidado de no cortar los laureles que se establecen. Se ha demostrado que unas pocas sencillas operaciones silviculturales pueden redundar en altos rendimientos y ganancia (*67*). El corte a matarrasa no se practica con el propósito de regenerar el laurel sino más bien para establecer pastos; pero es muy posible que con el precio siempre más favorable de la madera de laurel se llegue a establecer prácticas silviculturales con el objeto primordial de regenerar tan valiosa especie.

Conclusiones

El corte a matarrasa parece por lo tanto un sistema muy prometedor cuando las condiciones se combinan para favorecer un buen control en todas las etapas del sistema. Es preciso que el terreno una vez deforestado de su monte original, sea reforestado cuanto antes, unos pocos años a lo sumo. El hecho de que solamente puedan cultivarse especies que requieren luz abundante y de rápido crecimiento limitan considerablemente su aplicación. Sin embargo algunas especies valiosas poseen precisamente tales características y hay muchas otras que prometen tener buena demanda en el futuro cuando se conozcan mejor en el mercado. La producción rápida de madera de buena forma que puede ser cosechada bajo condiciones económicas favorables constituye hoy día una industria muy atractiva y el método de corte a matarrasa aparece como un instrumento silvicultural muy apropiado para lograr este propósito, siempre que se conozca muy bien la técnica y todas sus limitaciones.

Regeneración por medio del Enriquecimiento Artificial del Bosque en Franjas

Este sistema que goza de mayor popularidad en Africa y en especial en las colonias francesas consta esencialmente en abrir franjas de ancho variable en medio del bosque y plantarlas —o en algunos casos se siembra— con especies valiosas que han sido cultivadas en el vivero y se encuentran especialmente adaptadas para su nuevo ambiente.

El sistema persigue diversos objetivos. Ante todo, en vez de cortar un bosque a matarrasa solamente se cortan franjas dentro de ese bosque. Así se economiza mano de obra, se mantiene en mayor grado el ambiente natural y sobre todo se persigue un importante objeto silvicultural que es procurar luz por encima y sombra lateral a fin de que los arbolitos crezcan derechos y no ramifiquen desde temprano. El método parece ser muy satisfactorio si uno se mantiene en consideraciones teóricas. La práctica sin embargo ha demostrado que también es encuentran serias limitaciones y aún cuando en algunos casos han sido favorables, los resultados no siempre han justificado las esperanzas. También aquí es importante considerar primero las características ecológicas de las especies que se pretenden reproducir. Casi siempre se utilizan especies relativamente intolerantes a la sombra y de rápido crecimiento. Así mismo el estado del bosque en el cual se van a abrir estas franjas resulta importante pues se han obtenido resultados diferentes según se trate de bosques secundarios bajos o primarios altos. Finalmente las condiciones económicas, especialmente en cuanto a mano de obra necesaria para la apertura y el mantenimiento de dichas franjas, merecen serias consideraciones.

El intervalo entre las franjas es variable en las diversas zonas donde el sistema ha sido

practicado. En la Costa de Oro es 20 metros (una cadena) entre franjas mientras que éstas se abren sobre una anchura de 1,80 metros (6 pies). Las plantas obtenidas del vivero y despojadas de sus hojas se plantan cuando tienen 3-5 pies de alto (0,90-1,50 m) a una distancia de 10 metros (33 pies) dentro de las franjas (*4*). Sin embargo, hubo luego necesidad de limpiar continuamente las franjas y evitar repetidas transgresiones del bosque vecino, aumentando considerablemente los gastos. En la Costa de Marfil fué preciso ensanchar las franjas que originalmente se habían hecho a 10 metros de anchura hasta 25 metros para disminuir repetidas y costosas limpiezas (*17*). Problemas parecidos fueron encontrados por de Fays y Huygen (*43*) en la misma colonia. Este último autor sugiere que solamente deben abrirse parcelas de 4 x 4 metros cada 10 metros dentro de las franjas en las cuales se planta o siembra a una distancia de 1 metro por lado, también con el objeto de mantener los costos de mantenimiento al mínimo. Las especies con las cuales estos silvicultores trabajaron eran todas bastante intolerantes o sea que necesitaban grandes cantidades de luz y no podían soportar la competencia de árboles adyacentes en el espacio aéreo y posiblemente también en el suelo. La importancia de la cantidad de luz y de sombra es bien conocida en la silvicultura tropical. Wadsworth (*78, 79*) llegó a la conclusión de que de tal balance dependía la actividad destructora de los bejucos y otras especies nocivas que necesitan mucha luz. Por eso sugiere que cualquier apertura del bosque debe mantenerse dentro de ciertas limitaciones y calcula que un 60 por ciento de sombra es suficiente para que los árboles mantengan buena forma y se evita excesiva actividad de los bejucos. En algunos bosques de Puerto Rico, dicha apertura puede hacerse exclusivamente sacando algunas especies de valor para postes y en esta forma, los costos iniciales de preparación pueden reducirse en un 30 por ciento. Las exigencias de sombra lateral son tan específicas en algunos casos que Dawkins (*35*) informa un caso en Uganda donde se plantan especies nodrizas de *Cassia siamea* Lamb. o *Eucalyptus* spp. a fin de proveer sombra lateral a las plantaciones de *Chlorophora excelsa* (Welw.) Benth.

Posiblemente el defensor más ardiente de este sistema sea el conocido dasónomo tropical A. M. Aubréville quien en una larga serie de artículos (*10, 14, 16*) informa los éxitos alcanzados así como varios de los inconvenientes encontrados hasta la fecha. Algunas de las experiencias datan de más de 20 años. Las conclusiones a las que se puede llegar después de estudiar las observaciones de Aubréville indican que hay grandes variaciones en las diferentes regiones y con distintas especies. Los mejores éxitos comprueban que las especies más adaptadas son las más intolerantes aunque generalmente no tan intolerantes como para adaptarse sin restricciones al cultivo de plantaciones puras. La caoba africana (*Khaya senegalensis* A. Juss y otras *Khaya* spp.) y el okoume (*Aucoumea klaineana* Pierre) en particular han tenido éxito. Sin embargo nunca era posible eliminar completamente los cortes de limpieza de la vegetación natural que se establecía sobre la franja abierta, y del monte lateral que extendía sus ramificaciones tratando de cerrar la brecha abierta. Aún 20 años después, hubo todavía necesidad de liberar algunos arbolitos en una plantación cuyas franjas de una anchura de 10 metros se habían abierto cada 20 metros dentro del bosque, con arbolitos plantados cada 5 metros dentro de la franja. También se informan ataques leves de un, hongo (*Pestallozia*) y de algunos insectos aunque nunca en escala alarmante. Las plantaciones de *Chlorophora excelsa* (Welw.) Benth también fueron atacadas por otro insecto (*Phytolina lata*) (*46*).

Los costos incurridos para establecer dichas plantaciones han sido estudiados en diferentes lugares. Le Ray (*60*) informa que se necesitaron 136 hombres —días por hectárea al cabo de 5 años, pero Bellouard (*25*) solamente menciona 47 y 57 hombres—días por hectárea para dos plantaciones de 15 años de edad que tenían respectivamente 243

y 221 árboles supervivientes por hectárea. Ambos experimentos se realizaron en distintas zonas africanas.

Hay un punto importante en el que todos los silvicultores que han practicado este sistema se encuentran unánimes y es que las posibilidades de éxito son mayores cuando el bosque a tratar es de tipo secundario de mediana altura. Cuando es primario con árboles muy elevados, resulta difícil controlar el dosel (*9, 65, 25*). Wilten (*82*) menciona que es importante eliminar previamente los árboles gigantes mediante el anillamiento. Los bosques secundarios, por cierto se encuentran generalmente cercanos a los centros de población lo que facilita la mano de obra y posiblemente resulte en mercados para algunos de los productos provenientes de la apertura de las franjas y de posibles raleos en las etapas posteriores.

En América, existen plantaciones en franjas en terrenos de la United Fruit Company en la América Central y por iniciativa de algunas compañías madereras mexicanas. Las especies usadas fueron mayormente cedro (*Cedrela mexicana* L.) y caoba (*Swietenia macrophylla* King). Es prematuro emitir un juicio definitivo sobre la bondad del sistema hasta conocerse datos técnicos y económicos, pero aparentemente los problemas de competencia del monte adjacente a las franjas resultaron igualmente en altos costos de mantenimiento.

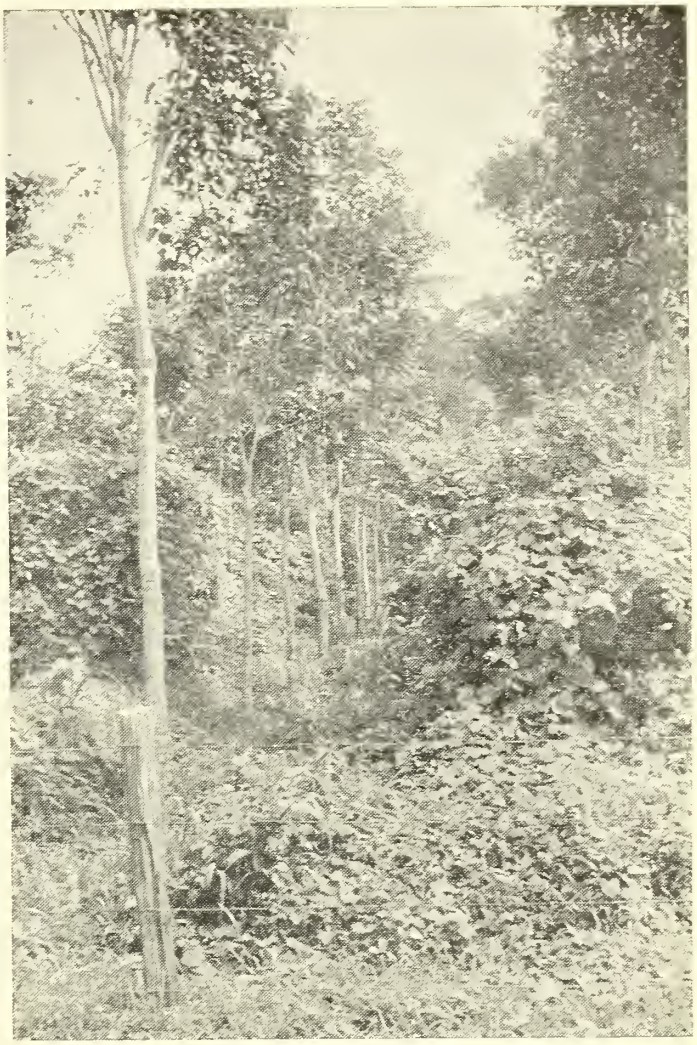

Fig. 1.—Plantación de caoba (**Swietenia macrophylla** *King) en franjas cortadas en un monte secundario. Costa Norte de Honduras; elevación aprox. 50m. (Plantation of Honduras mahogany* (**Swietenia macrophylla** *King) underplated in strips in a secondary forest in the northern coast of Honduras; elevation approximately 50 m.)*

La Siembra Directa y sus Variaciones

Una importante variación de este sistema consiste en la siembra directa sobre las franjas así abiertas en vez de plantar arbolitos. En Africa, se ha practicado con okoume (*Aucoumea klaineana* Pierre) (*60*). Con esta especie es importante sembrar muy rápidamente después de cosechar la semilla para no perder su viabilidad que dura solamente unas 3 semanas. En México el sistema se practica actualmente en gran escala con el cedro (*Cedrela mexicana* L.) en los terrenos calcáreos más bien secos del norte de la Península de Yucatán y en vez de franjas los que se siembran son los caminos madereros abandonados. Al cabo de 2 años, los brinzales de cedro se veían muy vigorosos y perfectamente saludables. Hasta entonces los ataques del temible taladrador (*Hypsiphyla grandella)* no habían causado estragos de consideración. Según los técnicos forestales

de esta región, se ha reforestado así unas 20.000 hectáreas surcadas de caminos madereros. Como también la semilla de cedro pierde rápidamente su viabilidad, era importante almacenar la semilla en frío después de cosecharla en febrero y abril y sembrarla cuando principian las lluvias fuertes en junio. En los caminos madereros secundarios donde habían pasado los tractores y los camiones la tierra estaba revuelta y expuesta, lista para recibir la semilla que un hombre lanzaba al voleo sin necesidad de enterrar. Aseguran los silvicultores mexicanos que dicho sistema reduce en 50 veces el costo de reforestación por hectárea si se compara con el método acostumbrado de plantar arbolitos del vivero en las franjas previamente abiertas. La densidad de los arbolitos es tal que muy pronto algunos raleos se estiman necesarios. El uso de semillas elimina la necesidad de hacer semilleros y viveros y transplantar los brinzales al campo, a un costo elevado. Sin embargo es necesaria una gran cantidad de semilla para sembrar así extensas regiones. Además es importante almacenar la semilla en frío. Finalmente hay que considerar la cuestión de mano de obra necesaria para recolectar la semilla pero todos estos inconvenientes parecen susceptibles de subsanarse con un mínimo de inversión y organización. La idea de almacenar semilla y sembrarla cuando principian las lluvias sobre los caminos madereros secundarios donde la tierra mineral ha sido expuesta, es posiblemente muy sencilla pero puede ser de grandes alcances en la silvicultura del trópico, si es que la experiencia de México puede aplicarse en otros países y con otras especies. Es interesante observar que la silvicultura del cedro se había estudiado mejor que cualquier otra especie del trópico americano sin lograr hasta la fecha su regeneración satisfactoria.

*Fig. 2.—Regeneración del cedro (***Cedrela mexicana** *L) originada por siembra al voleo sobre caminos madereros abandonados. Terrenos calcáreos en Yucatán, México: elevación aproximada 30 metros. (Regeneration of Spanish Cedar (***Cedrela mexicana** *L.) regenerated by broadcasting over abandoned logging trails of calcareous soils in Yucatán, Mexico. Approximate elevation 30 m.).*

El procedimiento mexicano puede combinarse muy satisfactoriamente con la explotación maderera sin desviarse de las prácticas rutinarias, particularmente en aquellas regiones donde el bosque es seco (o tropófilo o decíduo) con una estación seca bien marcada que limita las explotaciones madereras a unos pocos meses e implica la construcción de caminos madereros provisionales. En todo caso el método mexicano tiene a su favor un costo sumamente reducido y sería interesante que otros países americanos experimenten en forma similar.

Regeneración Bajo Dosel Protector o "Shelterwood"

Desde hace mucho tiempo, los dasónomos tropicales habían venido observando que muchos árboles valiosos pueden reproducirse satisfactoriamente bajo la sombra natural del bosque. Sin embargo solamente en fecha muy reciente ha podido aplicarse esta observación conduciendo al sistema de regeneración bajo dosel protector (más conocido por su nombre inglés de shelterwood), que goza actualmente de mucho favor (*70, 62, 39, 71*). No solamente se asegura la regeneración de especies valiosas sino que parece que el crecimiento de los brinzales es muy satisfactorio.

Esencialmente se sigue un proceso natural tal como acontece sin la intervención del hombre pero se trata de acelerar y seleccionar las especies más comerciales. Es por esto que la palabra "refinar" ha sido usada para dar la idea de que realmente se está convirtiendo un bosque heterogéneo, donde la mayoría de las especies tienen poco valor, en otro de composición florística más reducida pero en cambio mucho más valioso en sus productos (*36*).

Las Diferentes Fases del Sistema de de Regeneración bajo Cubierta Protectora

Dos operaciones principales forman generalmente parte del proceso de refinamiento de los rodales: (a) el corte inicial para inducir una buena germinación y favorecer el desarrollo de los brinzales y (b) los cortes de liberación para favorecer el crecimiento de los brinzales y posteriormente de los arbolitos jóvenes, hasta eliminar totalmente el dosel protector. En algunos casos muy favorables ambos cortes pueden redundar en uno solo en el que consideramos en primera instancia.

El Refinamiento de los Bosques de *Dipterocarpáceas* en Malaya y sus Repercusiones para la América Tropical

La naturaleza particular de estos bosques con un alto porcentaje de especies valiosas permiten su refinamiento en lo que puede considerarse la forma más sencilla del sistema de regeneración bajo cubierta protectora en los trópicos. Sin embargo aún con todas las condiciones favorables esta nueva técnica es de introducción relativamente reciente y cosa extraña, el resultado de lo que anteriormente se consideraba una práctica destructiva. Efectivamente cuando hace poco se reemplazaron los métodos primitivos de explotación por los métodos mecanizados a base de tractores se pensó que debido a la remoción de un número considerable de árboles por hectárea, el bosque no podría sobrevivir tanto daño. Sin embargo se hizo aparente que una cantidad muy satisfactoria de brinzales, a veces 600 o más por acre (1500 por ha.) se encontraba presente al año de tal explotación (*80*). Otras investigaciones revelaron que en los sitios donde el viento había causado extensos daños o donde se había explotado el bosque en forma intensiva bajo la reciente ocupación japonesa, el resultado era igualmente satisfactorio y una nueva generación estaba abriéndose paso debajo de los residuos. Podría pensarse que los métodos modernos de explotación implican el corte a matarrasa, pero no ocurre así. En esta zona no se favorece el corte total puesto que una gramínea muy agresiva (*Imperata* sp.)viene a establecerse y resulta luego muy difícil de eradicar (*83*). En realidad aún en los bosques dipterocarpáceos más ricos siempre queda una cantidad bastante considerable de especies que por una razón u otra no se

consideran económicas y éstas quedan en pie después de cosecharse los árboles maderables. Parece que evidentemente la regeneración presente en el momento de la explotación solamente estaba esperando esta liberación a fin de poder progresar en su desarrollo.

La remoción de una parte considerable de la cubierta les ofrece esta oportunidad y así mismo favorece la germinación y el establecimiento de una nueva valiosa regeneración. Cierto es que tal reproducción incluye otra vez un gran número de especies distintas y muchas de ellas pueden ser de poco valor, pero en esta edad se pueden eliminar las especies indeseables con relativa facilidad y bajo condiciones económicas muy favorables (*21, 81*).

El sistema se practica en gran escala en Malaya en la actualidad y los permisos madereros se conceden sin limitaciones en cantidades de madera que ha de cortarse en terrenos nacionales; hasta se requiere que los árboles remanentes no comerciales sean removidos o matados, anillándolos o envenenándolos con silvicidas. Estos últimos son substancias químicas que se aplican a los árboles y que al entorpecer su fisiología, causan la muerte del árbol. Sin embargo es importante que los contajes previos indiquen cantidades adecuadas de reproducción deseable antes de permitirse la explotación y hasta puede llegar a ser necesario esperar buenos años con abundante semilla. La apertura súbita provoca un aumento considerable en la actividad de los bejucos y un manto vegetativo se desarrolla sobre el nuevo dosel de los arbolitos. Parece sin embargo que ésto no afecta demasiado a los brinzales y eventualmente éstos son capaces de salvar este obstáculo, un comportamiento bastante extraordinario que difícilmente puede encontrarse en otros países tropicales cuyos bosques han sido sometidos a intervenciones parecidas. Con todo ésto, las limpias siempre se hacen necesarias a su debido tiempo y se llevan a cabo en los años subsiguientes además del primer raleo.

Sin duda la característica más favorable de los bosques de Dipterocarpáceas es la presencia de una regeneración abundante bajo la cubierta natural. Condiciones parecidas han sido descritas para otros bosques tropicales aunque solamente parece encontrarse en rodales que no han sufrido mayores perturbaciones o asociaciones especiales como los bosques del pantano (*39, 62, 24, 63, 40, 68*). Es corriente en bosques americanos donde las semillas de los árboles son pesadas tales como en *Mora* spp., *Prioria copaifera* Gris. (*20*), *Carapa guianensis* Aubl., *Virola* spp., todas especies importantes comercialmente. En algunos de los bosques del Sureste de Asia casi siempre se encuentran asociaciones relativamente puras o formando una proporción considerable del rodal, en forma muy parecida a las Dipterocarpáceas. Carecemos de información sobre la aplicación del sistema de regeneración bajo cubierta protectora en estos bosques pero se sabe de algunos casos donde el corte a matarrasa no deja que el bosque se reproduzca en su forma original aún cuando unos brinzales se encontraban en la sombra. Otras especies inferiores y de muy rápido crecimiento fácilmente los ahogan.

Los Cortes Iniciales para Inducir Regeneración

Las condiciones favorables de los bosques de Dipterocarpáceas pueden estimarse como excepcionales si se comparan con otros países (*32*). En el caso americano la mayoría de los bosques suficientemente acequibles para justificar operaciones silviculturales de alguna intensidad son a menudo de tipo secundario y usualmente degradados. Las especies más valiosas han sido explotadas y muchas especies indeseables han alcanzado un tamaño enorme. Por otra parte, la presencia de grupos de población a corta distancia significa que buenos mercados pueden encontrarse para leña, carbón y maderas de construcción de tamaño variable, una ventaja importante cuando se quiere practicar este sistema, puesto que puede bajarse el costo de algunas de las operaciones iniciales y hasta arrojar algunas

ganancias; (*18, 77, 53*). En vista de lo degradado del bosque, una buena regeneración natural se encuentra usualmente escasa. Los árboles deseables y proveedores de semilla puede que no estén presentes en cantidades suficientes en el bosque o solamente dispersos en pequeños grupos aislados. Debido a las prácticas deficientes de explotación al fuego y el pastoreo irracional, muchas malas especies han invadido los claros y un sotobajo puede cubrir densamente la capa inferior del bosque. La mayoría de los bosques de India, Africa y la América Tropical se encuentran en esta categoría, sobre todo cerca de centros de población. Si la fuente de semilla es completamente insuficiente, resulta evidente que el sistema de regeneración bajo dosel protector no puede aplicarse del todo y hay que utilizar otro sistema que implique la reforestación artificial (*71*). Sin embargo, hay pruebas suficientes de que aún en el caso de existir pocos árboles productores de semilla de especies deseables todavía puede lograrse una buena regeneración cuando el bosque ha sido sometido a algún tipo de intervención (*74*). En la América Tropical esto es frecuentemente el caso con especies valiosas tales como *Cordia alliodora* R. & P. (Cham), *Cedrela mexicana* L., *Swietenia macrophylla* King, *Astronium graveolens* Jacq., *Bombacopsis quinatum* y otros. Hasta algunas de las especies tolerantes a la sombra, con semillas no aladas o pesadas como las pertenecientes a la familia de las Lauraceas pueden aparecer entre la regeneración a pesar de la ausencia de árboles cercanos semilleros; evidentenmente ésto se debe a la actividad de los pájaros y los murciélagos (*40*).

Esencialmente entonces, el silvicultor deberá tratar de imitar o mejorar estos procesos naturales favorables y aplicar la mejor técnica sobre una extensión mayor y bajo las menores condiciones económicas. Como regla general ésto se consigue mediante la apertura regulada del rodal pero es de suma importancia considerar la fecha del corte, la clase de árboles escogidos para eliminarse y las medidas utilizadas para lograr este propósito.

En Nigeria, Africa, se encontró que algunas operaciones iniciales de los rodales favorecen definitivamente la germinación, así como los brinzales que ya se encontraban presentes. Siempre el grado de apertura del bosque logró un efecto marcado sobre el tipo de regeneración que se obtuvo. Con cortes livianos, el número elevado de especies tolerantes aparecieron pero luego tuvieron mucha dificultad en seguir desarrollándose. Por otra parte los cortes demasiado severos favorecieron las especies intolerantes así como los siempre indeseables bejucos y otras malas hierbas. En vista de que la regeneración deseada incluía especies tanto tolerantes como intolerantes, se decidió que la secuencia correcta sería una apertura ligera para el primer año seguida por aperturas mayores posteriormente. En esta forma, las especies tolerantes podrían establecerse ventajosamente y luego ganar suficiente ventaja para resistir a la competencia de sus vecinos ulteriores más agresivos. Estas operaciones solamente tuvieron éxito cuando el bosque tenía una estructura normal o sea una buena proporción de árboles ocupando sus diferentes niveles. Si había exceso de árboles sobremaduros, o si los árboles más viejos estaban del grosor de postes (no más de 10 pulgadas o 25 cms.), no era posible regular satisfactoriamente las aperturas y conseguir los efectos deseados. Igualmente era necesaria la presencia de un suficiente número de árboles productores de semilla (*72*). El valor comercial del bosque era de menor importancia.

En Trinidad se han podido lograr éxitos espectaculares a pesar de que el bosque originalmente tratado estaba muy degradado (*18, 23, 26, 8*). Aquí se hizo una apertura intensa del rodal en los estratos inferiores e intermedios manteniendo una cubierta alta. Se pudo conseguir la cooperación de los carboneros los que cosecharon las especies no comerciales. La regeneración deseada resultó muy abundante y brinzales de 8 especies diferentes de valor comercial se desarrollaron

con todo éxito. Algunos provenían de semillas aladas mientras que otros evidentemente fueron traídos por las aves justificando así la importancia de dejar árboles con el sólo objeto de proveer abrigo para las aves que en esta forma dejan la semilla con sus deposiciones. Una limitación del sistema es que en Trinidad dicha regeneración natural solamente pudo conseguirse en suelos arenosos pero no ha sido eficiente en arcillas.

En la Guayana Británica se practicó con muy buen éxito el mismo sistema en los bosques de greenheart (*Ocotea rodiei* (Schomb.) Mez eliminando completamete el estrato inferior o sotobajo con excepción de los brinzales de greenheart y cortándose todos los bejucos. También se extrajo parte del dosel según las condiciones del bosque (*19*).

Cuáles Arboles Deben Cortarse

La importante posibilidad de cosechar algunos árboles que han de eliminarse durante estos cortes (que han de favorecer la germinación) nos lleva a considerar cuáles árboles y qué otras especies deben seleccionarse para cortar primero (*77*) y en qué momento durante las operaciones.

Los silvicultores tropicales están prácticamente unánimes en decidir que todos los bejucos deben eliminarse cada vez que se efectúa algún corte. Los bejucos son sumamente molestos y su actividad está siempre en oposición con la mejor producción de madera comercial (*36*). Su actividad aumenta cuando el rodal se abre demasiado y su crecimiento es extraordinariamente rápido. Es necesario eliminarlos en las etapas iniciales del proceso de refinamiento ya que pueden agarrarse de diferentes árboles adyacentes y amarrarlos, dificultando así posteriores operaciones de tumba. Aparte de los bejucos, los árboles susceptibles a eliminarse caen dentro de las siguientes categorías:

1. Arboles de tamaño pequeño. Muchos de ellos nunca pasarán de cierto tamaño, generalmente desarrollan una forma pobre y raras veces pueden considerarse de importancia económica. Junto con los árboles suprimidos, ocupan los estratos inferiores dentro de la estructura del bosque y son los primeros en eliminarse.
2. Arboles muertos. Si pueden venderse deben cortarse puesto que su habilidad para proveer sombra es mínima. Su presencia realmente no es perjudicial exceptuando la posibilidad de servir de agarre a los bejucos.
3. Arboles sobremaduros. Ocupan un espacio considerable y tarde o temprano han de ser eliminados aunque ésto debe hacerse cuidadosamente. Su remoción súbita deja un gran claro. Es por ello muy conveniente anillarlos o envenenarlos con silvicidas cuyo uso se discutirá más adelante.
4. Arboles maduros de mala forma o especies indeseables que alcancen el dosel superior.
5. Arboles maduros de especies indeseables o de mala forma.
6. Arboles maduros de especies deseables y buena forma.

Como puede apreciarse existe un margen considerable en la selección de los árboles que han de ser eliminados en la etapa inicial a fin de lograr el grado máximo de eficiencia en dicha apertura. Hasta puede pensarse en cosechar algunos de los árboles comerciales, lo que sin duda constituye una posibilidad atractiva. Sin embargo es importante comprender que dicha oportunidad nunca debe llegar a desviar el interés del objetivo primordial que es lograr una regeneración adecuada de especies deseables. Desgraciadamente es frecuente la tentación de una ganancia prematura cosechando algunos árboles de valor, arruinando de una vez todas las posibilidades posteriores de reproducción. La política primordial debe ser siempre la remoción de todas las especies indeseables primero, dejando las especies valiosas como fuente de semilla. Solamente en el caso de un bosque con árboles semilleros abundantes y de especies valiosas puede considerarse la posibilidad de efectuar algunas cortas de madera.

Donde Debe Concentrarse el Corte Inicial

Las experiencias africanas y americanas también indican que la mayoría de las operaciones deben concentrarse en los estratos intermedios e inferiores del bosque dejando provisionalmente una cubierta en el estrato superior.

Aún la remoción del sotobajo o estrato inferior no ha sido siempre muy favorable. La idea está naturalmente en procurar una buena camada para las semillas (*43*). Frecuentemente la germinación es adecuada sin necesidad de algún tratamiento especial. La mortalidad más seria ocurre casi siempre después de germinar, durante el desarrollo del brinzal y aquí es donde se necesita la mayor asistencia. La reprodución abundante que se encuentra usualmente bajo los bosques no perturbados es buena prueba de que la germinación generalmente ocurre bajo condiciones normales de espesura del sotobajo. Ya se mencionó que en los bosques de Dipterocarpáceas no resultó necesario remover el sotobajo. En otras regiones sin embargo, los efectos de dicha intervención resultaron deseables. Así, Jacob (*55*)describe una situación en Assam, India, donde se hizo un intento de compensar la escasez de árboles semilleros deseables mediante la limpia del suelo. Esto se combinó con la remoción de la mayoría de los árboles de los estratos inferiores y medianos del rodal en un radio de 20 a 30 pies (6 a 9 metros) alrededor de los árboles semilleros. Así se obtiene excelente regeneración pero en vista de las distancias a veces grandes entre los sitios tratados, las operaciones silviculturales posteriores fueron más bien engorrosas y en general carecía de cierta unidad. Algunos de estos claros luego atrajeron elefantes y búfalos y otros animales que causaron extensos daños mayormente por pisoteo. El sistema por lo tanto se revisó a favor de cortes iniciales menos severos seguidos por aperturas graduales en las etapas posteriores. En el Sur de India, aún la remoción del sotobajo no fué suficiente para inducir la reproducción de especies tan valiosas como *Dysoxylum malabaricum* Bedd. En cambio otras especies menos deseadas se aprovecharon. Solamente después de tomar medidas extremas tales como aflojar el suelo poco antes de la caída de la semilla, limpiar frecuentemente y hasta fumigar las semillas para prevenir el ataque de insectos, pudo conseguirse la reproducción deseada (*66*). Esto sin embargo es llevar las cosas al otro extremo y es dudoso que se pueda seguir el mismo procedimiento en otros países donde la mano de obra no es tan barata como en la India. Se llega a pensar si en el caso precedente no hubiera sido preferible utilizar material de vivero, con mejores resultados técnicos y aún económicos.

Para concluir, parece que la remoción del sotobajo y la preparación de camadas resultan necesarias en algunos casos, pero no esencialmente en otros. Una buena cantidad del sotobajo se elimina de todas maneras y hasta se consigue cierta perturbación en el suelo cuando los obreros están cortando los estratos intermedios en este sistema (*57*).

Cortes de Liberación

Una vez que se ha conseguido la regeneración adecuada, el dosel debe eliminarse gradualmente. Ya se discutió la selección de las especies que han de eliminarse pero en los cortes de liberación, el valor del árbol individual es mucho menos importante que la calidad y cantidad de la sombra que provee para la nueva generación. Así mismo es importante considerar el método con el cual han de eliminarse los árboles viejos.

Mientras que el dosel se elimina gradualmente, los brinzales y postes pequeños demandan continuo cuidado para lograr su mejor desarrollo (*78, 79*). La remoción demasiado rápida del dosel favorecerá los bejucos y el establecimiento de especies invasoras indeseables mientras que la presencia de un dosel demasiado denso obstaculizará el crecimiento de los arbolitos. En Malaya, la remoción completa del dosel pudo lograrse en solamente 2 á 3 años, pero luego fueron necesarias diversas operaciones intensivas de

limpieza y liberación a fin de proteger los arbolitos contra los bejucos y otros enemigos. En otros lugares puede transcurrir un período de 5 o más años antes de que la nueva generación pueda dejarse enteramente al descubierto (*72*).

Parece imposible llegar a algún tipo de generalización en relación con el número de cortes a lo largo del período sobre los cuales han de extenderse ya que las condiciones son muy variables según las localidades. El mejor criterio que ha de usarse estará basado en frecuentes observaciones y contajes de los brinzales que reflejen las condiciones de la nueva cosecha. Siempre que se efectúa alguno de estos cortes, parece aconsejable acompañarlo de una buena limpieza alrededor de los pequeños arbolitos de valor. Siempre debe tenerse en mente la eliminación de bejucos.

Silvicidas y Anillamiento

La reciente introducción de silvicidas en la dasonomía tropical está llamada a contribuir considerablemente a la práctica de una silvicultura con mejores posibilidades económicas. El sistema de regeneración bajo dosel protector parece ser especialmente favorecido. La remoción por corta de árboles de troncos cortos, gruesos y de copas anchas constituye un serio dilema considerando que el anillamiento a menudo no resulta eficiente. Si el árbol se tumba, sus restos no solamente dañarán considerablemente la reprodución de la valiosa regeneración, sino que se deja un enorme hueco y sus restos proveerán un magnífico sostén para los bejucos. Sin embargo, si el envenenamiento puede substituir al corte, los resultados son altamente satisfactorios. El árbol se seca lentamente y las especies contiguas aprovechan el espacio. Las ramas al morir se desprenden cuando son relativamente livianas, y cuando el resto del árbol finalmente cae a tierra el daño que causa es mínimo.

Más que todo, el envenamiento tiene la ventaja de abrir el dosel en forma gradual, evitando así la entrada súbita de mucha luz. Este detalle es importante puesto que los bejucos se controlan, hasta cierto punto y también resulta más conveniente para los requisitos de la nueva generación. El efecto es similar al que generalmente se persigue en los viveros cuando la sombra intensa se elimina gradualmente.

No parece haber beneficio en anillar o envenenar los árboles pequeños a menos que sus retoños sean excesivamente dañinos y puedan llegar a entorpecer el desarrollo de la nueva cosecha. Sin embargo, de acuerdo con *Bernard* (*21*), los bejucos pueden envenenarse y sugiere remojar el extremo cortado del bejuco con una solución de 1 libra por galón de agua (aproximadamente 12 por ciento) en Arsenito de Sodio, a fin de evitar los retoños.

La práctica de anillar *Cecropia peltata* L., una especie invasora americana, ha demostrado ser muy efectiva en Puerto Rico. Esto plantea la posibilidad de utilizar esta especie como árbol nodrizo debido a su rápido crecimiento y a la facilidad con que puede eliminarse anillándolo. Las observaciones en las diferentes fases sucesionales de los bosques tropicales americanos confirman que las *Cecropia* spp. ofrecen excelente abrigo para el desarrollo inicial de muchas especies valiosas.

Con árboles más grandes el envenamiento con substancias tóxicas, llamadas "silvicidas" resulta usualmente muy eficiente. En Nigeria el Arsenito de Sodio demostró ser muy eficiente (*72*). En Malaya el anillamiento y el envenenamiento son ampliamente practicados. Sin embargo, debido a la alta toxicidad del Arsenito de Sodio se han informado casos de envenenamiento de animales (*5*). Es posible sin embargo que su substitución por compuestos menos tóxicos resuelva este problema. Existen hoy día muchos silvicidas en el mercado y algunos de ellos han probado ser altamente satisfactorios sin ser tóxicos para los animales. Compuestos como el 2-4-D, el 2-4-5-T y el ammato han sido utilizados con mucho éxito en los Estados Unidos pero hasta la fecha se carece de datos para los bosques tropicales, especialmente para los dos primeros.

Ciertos árboles excepcionalmente grandes, pertenecientes a determinadas especies, puede que resulten difíciles de envenenar efectivamente. Mientras que en algunos casos la corteza es extremadamente gruesa, otros tienen una forma peculiar del tronco (acanalado, con enormes aletas o raíces tablares, etc.) que dificulta la tarea de su eliminación. Jacob (*55*) informa que grandes árboles de *Ficus* lograron restablecerse al año después de haber sido envenenados, aún cuando por un tiempo se veían en muy malas condiciones. Sin embargo, es de esperar que eventualmente se consiga algún método efectivo que pueda vencer tales dificultades.

Mientras tanto se pueden lograr mejoras considerables usando las técnicas adecuadas en la época propicia del año y bajo las condiciones económicas más favorables. Barnard (*22*) después de revisar los métodos de envenenamiento usados en el sistema de regeneración bajo cubierta protectora en Nigeria, encuentra que muchas operaciones molestas muy bien hubieran podido substituirse por otras más efectivas y baratas. Así en vez de trepar los árboles con grandes raíces tablares a fin de envenenarlos más arriba, sugiere cortar en forma de anillo alrededor del tronco (frill girdling) y verter el veneno en las ranuras abiertas, aún cuando ésto tenga que hacerse sobre las raíces tablares. Así el obrero puede operar a la altura más conveniente. Además, las operaciones de envenenamiento deben efectuarse durante la estación de las lluvias y no en la estación seca, cuando el crecimiento está menos activo.

Ventajas y Desventajas del Sistema de Regeneración Bajo Dosel Protector Sobre Otros Métodos

Ventajas:

1. La operación sigue esencialmente los procesos naturales y no implica un cambio radical como lo sería el corte a matarrasa.
2. No es necesario hacer semilleros y plantaciones.
3. Parece que hay menos peligros de ataques de hongos e insectos, puesto que se sigue un procedimiento natural.
4. El suelo siempre se mantiene bajo alguna cubierta protectora de vegetación arbórea.
5. El sistema puede usarse tanto con especies tolerantes como relativamente intolerantes de crecimiento lento o rápido.
6. La nueva cosecha desarrolla buena forma durante los años iniciales ya que la sombra prevaleciente estimula su crecimiento en altura y evita tempranas ramificaciones.
7. El control de la sombra limita la entrada de especies invasoras indeseables y hasta cierto punto restringe la actividad de los bejucos, necesitándose menos limpias.
8. Existe buena protección contra agentes meteorológicos dañinos.
9. El sistema puede usarse con especies de semillas pesadas.
10. El sistema cuando es factible, parece más económico que cualquier otro.

Desventajas:

1. El sistema no puede usarse con especies muy intolerantes o sea muy ávidas de luz.
2. La cosecha de especies valiosas puede que no sea factible en vista de que el pequeño número de árboles deseables se necesitan usualmente como fuente de semilla y una vez que la regeneración se establece, su remoción puede ser dañina a la nueva cosecha. Tales inconvenientes parecen particularmente importantes cuando se llega a la segunda rotación. Esta vez habrá que cosechar un número mucho mayor de especies. Sin embargo, es muy posible que entonces el bosque se comporte en forma similar a las Dipterocarpáceas anteriormente descritas; la gran cantidad de árboles deseables proveedores

de semilla asegura una abundante regeneración y la explotación puede efectuarse una vez que la regeneración se haya establecido profusamente. Sin embargo, éstos no son más que deducciones, ya que en ninguna parte del trópico se ha llegado a completar la primera rotación.

3. No puede usarse el sistema en rodales que han perdido su estructura regular o donde los árboles semilleros deseables son muy raros o ausentes. La dispersión de semillas por las aves y los murciélagos puede contrarrestar tales condiciones pero solamente hasta cierto punto.
4. El método requiere cierta pericia y un buen control sobre todas las operaciones.
5. Todavía subsisten algunas especies tolerantes que aún con este método no pueden regenerarse económicamente. Esto se debe más que nada a nuestra escasez de conocimientos silviculturales de dichas especies.

Los Resultados Alcanzados hasta la Fecha

Los informes de diferentes países donde se ha practicado el sistema de regeneración bajo dosel protector son altamente prometedores. No pasa mucho tiempo sin que se hagan mejoras, especialmente al acumularse más datos sobre la silvicultura de las especies tropicales. En algunas zonas, la política ha sido de pasar de otro sistema al de regeneración bajo dosel protector (*70*, *71*). La introducción reciente de los silvicidas promete favorecer enormemente este sistema, ya que existen muchas aplicaciones en varias de las operaciones. Muchos países tales como Nigeria, el Congo Belga y Malaya, están ampliando su programa de regeneración a través de este método. En la América, los datos de Trinidad, Guayana Británica y recientemente Costa Rica (*53*), donde se regeneró el *Astronium graveolens* Jacq. y Perú, con el *Cedrelinga catenaeformis* (*28*), han sido todos muy halagadores y auguran un excelente porvenir al sistema de regeneración bajo dosel protector.

RESUMEN

Los sistemas de regeneración de los bosques de bajura han sido últimamente objeto de muchas conjeturas a veces controversiales, en vista de numerosos fracasos y algunos éxitos. En el presente trabajo se pretende hacer una revisión de las experiencias adquiridas a fin de contribuir a programas silviculturales en el futuro.

Con el objeto de transformar el bosque heterogéneo poco productivo en otro de menos especies pero de alto rendimiento económico, se distinguen generalmente tres sistemas:

1. El corte a matarrasa seguido por la inmediata plantación de especies de alto valor. Solamente puede emplearse satisfactoriamente con especies heliófilas, de rápido crecimiento, con buena resistencia natural contra plagas y enfermedades, en zonas ecológicamente apropiadas y con buenas comunicaciones. La mejor utilización del bosque que ha de eliminarse y el uso temporario del suelo para agricultura (sistema taungya) aparecen muy deseables desde el punto de vista económico, pero requieren un control adecuado en todas las operaciones de este proceso.
2. El enriquecimiento artificial del bosque en franjas. Ha dado los mejores resultados en bosques de segundo crecimiento cerca de zonas pobladas. La siembra de semillas al voleo en caminos madereros abandonados poco después de iniciarse las lluvias, tal como se efectúa en Yucatán, México, aparece como una alternativa muy prometedora.
3. El sistema de regeneración bajo dosel protector (o "shelterwood"). Ha sido usado más ventajosamente cuando la estructura original del bosque no ha sido muy modificada, cuando hay

suficientes árboles proveedores de semilla y cuando las especies que han de regenerarse son más bien poco exigentes en cuanto a la luz. Usualmente los cortes iniciales tienden a lograr una reproducción adecuada mediante la apertura del rodal, particularmente en sus estratos intermedios y la remoción final de todo el dosel en etapas posteriores (cortes de liberación.)

El anillamiento y el envenenamiento de especies indeseables parecen ser prácticas muy efectivas para, junto con la cosecha de especies valiosas, asegurar la eliminación gradual del dosel protector y favorecer así el mejor desarrollo de la regeneración.

El sistema goza de la aprobación de un número creciente de silvicultores tropicales.

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Regeneration Systems in Tropical American Lowlands

(Translation of previous article)

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INTRODUCTION

One of the most important branches of tropical silviculture is undoubtedly the regeneration of mixed forests.

It is well known that current forest exploitation in most Latin American countries is really a negative selection of valuable species or "high grading", since only the best trees are cropped leaving the space open to other non-commercial species. With the addition of damage from repeated fires, uncontrolled grazing, shifting agriculture, and lack of regeneration practices, the overall picture is disheartening; it is easy to understand why the forest economy and welfare of many regions are in a deplorable state. Countries such as Cuba, El Salvador, and Puerto Rico, once covered with forests, are forced to import practically all their lumber needs and other forest products. To this may be added the fatal consequences on waterflow and the native fauna, and the absence or scarcity of recreation zones for urban populations. All these amount to a very high price for the lack of foresight. Many other countries have suffered a similar fate since few forested regions have been left close to population centers. Even in rural areas, prices for lumber, firewood, posts, and other similar products have become prohibitive in recent times.

It should not be assumed that Governments have remained indifferent. There is an accumulation of laws which, according to many Government officials, are apparently excellent. In practice, however, they are more or less disregarded. Despite continuous changes or rigid enforcements of these laws, the situation not appreciably changed for the better. Huge reforestation programs have been lauched, usually through free distribution of seedlings, a policy that unfortunately still seems to enjoy much popularity. Beard (*23*, p. *18*)[1/] once commented that: "Tropical forestry in nearly every country in which it has been practiced, has suffered in its youth from a disease that has been called "planting measles", a fixed idea that it was necessary to start forming plantations at great speed all over the place, often without any previous research. After the wastage of much money, the program was revised in favor of less costly, more natural methods, based on careful experiments."

The forest history in Latin America is full of these failures (*47*) and, although some have been publicized (*69*, *30*), most of them have never been reported. It is apparent, however, through the annual reports of the forest services of Ministries of Agriculture of many countries, that many seedlings have been distributed; later examination of planting sites corroborates the wastage in effort and money. This has been recently confirmed by the Guatemalan Forest Service, after an investigation undertaken concerning the fate of millions of seedlings distributed in recent years. The results were most disappointing. True, it is easier to criticise than to find definite solutions.

It is a primary requisite that wildfire and unrestricted grazing be controlled before any

1/ Numbers in parenthesis refer to Literature Cited, page 70.

attempt is made at forest regeneration. Even after this protection has been attained, many questions still remain unanswered. What species are to be used? How and when should they be planted? What care do plantations require? Perhaps instead of planting it is possible to induce natural regeneration through adequate interventions. Finally and more important than all previous interrogation - How can the desired result be achieved with a minimum of expenditures and a maximum of efficiency?

The answer to these questions is in the scope of this article. An analysis of past experiences, especially of successful ones, will give many clues. The practice acquired in other tropical countries wil be very useful since conditions are often duplicated. This presentation of experiences gained elsewhere may be useful as publications pertaining to silvicultural systems applicable in tropical America are limited.

It is Preferable to Work with Forest Soils

It should be remembered that it is easier to revert a denuded area into a forest whenever this happens on a forest soil rather than on a degraded savanna soil. The latter is usually more compact with deficient or excessive drainage and often with additional special problems. It is often an illusion to think that reforestation of areas ruined by repeated fires, shifting agriculture, and unrestricted grazing can be accomplished unless large sums are invested for irrigation, fertilizers, digging holes for planting, or raising costly nursery plants. If a watershed is to be reforested, probably the best thing to do, assuming an adequate seed source is to protect it so that natural succession towards forest may take place. If this process of natural succession is to be hastened, pioneer species should be used or natural seedlings should be liberated from weeds and grasses (*52*, *29*). At any rate, this is an arduous and costly process and certainly uneconomical if the goal is to obtain lumber or other direct forest products. Much easier, and with good economic prospects, is the regeneration of an existing forest, even if it is degraded.

CURRENT REGENERATION SYSTEMS USED

As a general rule, most of the forests are actually unproductive in an economic sense regardless of whether they are virgin or degraded. This is mainly because of their heterogeneous composition with only a small amount of commercial timber present, logging costs are usually high. Thus, it is generally agreed that an alteration of the composition, particularly in regard to structure and number of species, is highly desirable (*41*, *42*). This is what Dawkins (*37*) has called "refining" - to render the idea of conversion into more valuable material. However, this conversion should be made with due regard for ecological conditions so that the new stand to be formed will not only be healthy, but also self-sustaining and permanent (*63*).

The regeneration methods used fall currently into three broad groups (*38*):

1. Since the existing forest offers little of commercial value, clearfelling is practiced and the old stand is replaced by a more even-aged crop, recruited from artificial or induced natural regeration.
2. The stand is enriched by the artificial introduction of valuable species. This methodical underplanting is usually done in combination with systematic openings in the canopy in the form of lanes or strips of variable width and at different intervals within the forest.
3. Natural regeneration is induced under partial shade or protective shelter through careful and gradual opening of the stand. The purpose of such a gradual opening is to induce more and better reproduction and the development of a new, more valuable crop of trees. This system is generally known as "shelterwood". Spanish terminology translates it to "cortas uniformes o

cortas progresivas y aclareos sucesivos' (*44*) or "regeneración bajo cubierta protectora de pies de masa reservados, previa una corta a hecho o rasa, y otra ulterior" (48). In this paper, "regeneración bajo dosel protector" (literally: regeneration under protective canopy) is used.

Each of the three systems has its own best applicability, advantages, and drawbacks, and all factors must be carefully evaluated before deciding which to adopt. Even if some intergrading may occur it can, however, be said that one system can best be applied when certain definite conditions prevail. (*1, 43, 71*).

Regeneration Through Clearfelling

It is noticiable that this system faces almost automatically, the reproval of a good number of foresters who claim it is dangerous and too drastic. Although dangers may be found when the forest with all its favorable influences is removed, there is no question that under favorable conditions, this system has been very successful in different tropical lowlands.

Before going into details, it is advisable to review briefly the natural process that would follow clearfelling if no further intervention were made. It has been adequately demonstrated that the land will return to forest although the first arboreal vegetation that follows, i.e. the weed, brush and climber stage, is far from being similar in composition to the original stand (*1, 13, 53*). A number of fast growing species are the "invaders". Their seed is light and easily dispersed by wind. *Musanga* spp. and *Trema* spp. are the most common examples in Africa, while *Cecropia* spp., and to a lesser extent, *Ochroma lagopus* Sw., *Trema micrantha* (L.) Blume, and *Schizolobium parahybum* (Vell.) Blake are striking examples in Africa. These species usually have very soft wood which deteriorates rapidly after felling; only recently have they received any consideration for possible economic uses. They do not, however, persist indefinitely and give place to other species that germinate and grow under their shade. After several stages of succession it can be assumed that the whole stand will return to the composition of the original forest or at least something quite close to it (*45, 58*). However, if the soil is cultivated for several years following clearing, and this often happens when the usual method of shifting agriculture is used, a lower form of herbaceous vegetation, specially grasses, becomes established and is likely to persist for a considerable time (*81, 11*).

In the succeeding years, there is also a rapid deterioration of the soil since it loses its protective cover and remains exposed to rains and solar radiation (*26*). More than losses in organic matter and nutrients, this degradation involves soil compactation and the formation of hard pans, often iron concretions, with impeded drainage, especially on flat areas. If the vegetation is continuously kept down by fires, a poor, fire resistant savanna may be the final result.

This leads to the statement that if a valuable forest cover is to be established after clearfelling, it must be done very soon. Nursery grown stock is generally used in order to give the young seedlings an additional advantage in the race with the natural vegetation.

The "Taungya" System

Based on clearfelling, some of the most spectacular successes have been achieved with the taungya system originated in India. It is commonly used in Asia, Africa, and apparently with promising results in Trinidad and British Honduras. Essentially, it consists of using the forests for agricultural purposes during a limited time; the forest is felled, burned, and the land planted with crops. With the first rainy season, seedlings or root and stump cuttings of valuable tree species, are planted and cared for by the provisional

users of the land as a partial compensation for its use. When crops are weeded, so are the seedlings. When cropping is over and the area is abandoned, it is already planted. The young trees will not thrive without attention, to be sure, since several silviculture operations such as cleanings or thinnings are essential. Thus the operation starts with very little cost and actually there might be some profit because some of the fallen timber may be utilized or sold. The harvesting of excellent agricultural crops following deforestation is good compensation for nursery and plantation costs. A further refinement is achieved in Trinidad on crown forests where charcoal can be made profitably from the remaining species that are useless for timber. Teak (*Tectona grandis* L.) is then planted as root and stump cuttings. After 2 years, the same process is repeated in another region. So far, about 3,500 ha. (8,750) have been "converted" through this scheme (*8, 31*).

In the Belgian Congo, the taungya system has been successfully used in combination with banana planting. When located along or close to the rivers, the forests can be economically clearfelled because there is an excellent market for firewood for steamships. In both cases *Terminalia superba* Engl. & Diels is planted. Here too, the operation starts with a profit-yielding harvest but it is later necessary to keep the competing vegetation in check. In eastern Belgian Congo, good markets for firewood have made clearfelling a profitable operation. Here *Terminalia superba, Khaya grandiflora, K. anthotheca* and *Fagara macrophylla* were planted. All these species are fast growing and strong light demanders (*54*).

Other countries report similar experiences; in British Honduras pine (*Pinus caribaea* Morelet) is planted after the brodleaf forest is felled (*7, 64*), in India (*2, 56*), in tropical Australia (*9*), West Bengal (*6*), and on the island of New Britain in the Pacific Ocean in connection with the establishment of *Eucalyptus deglupta* Blume, a valuable and very fast growing native species (*49*). The taungya system has been applied in many African countries (*3*) and in many parts of the tropics in general.

As can be seen, the characteristic features of the taungya system are the planting of valuable, fast growing, and light demanding species; the best economical utilization of the forest; and the temporary short cultivation of the soil, related of course, with the special land tenure pattern. When one or more of these factors is lacking, the system is likely to become expensive or entirely impracticable. In case there is not enough demand for farming land, or when the population is not accustomed to a rotating or shifting system of agriculture, or when all the different processes of the system cannot be adequately controlled, serious handicaps may arise and failures are to be expected (*4, 61*). In Honduras, Guatemala, and other Central American countries, the United Fruit Company as well as other private owners have established some plantations, especially with teak (*Tectona grandis* L.), primavera *(Cybistax donell-smithii* (Rose) Seibert), mahogany *(Swietenia macrophylla* King) and *Eucalyptus deglupta* Blume. There were heavy initial investment because apparently little or no use was made of the fallen timber and the soil was not cultivated. According to the Fruit Company, however, the high value of the new-grown timbers will compensate for the investment. Apparently this is also the case in other places where similar plantations have succeeded with mahogany in the Philippines (*34*), with okoume (*Aucomea klaineana* Pierre) in Martinique (*33*) and in Africa (16).

Some experiences with the genus *Eucalyptus* have been particularly successful, both at higher and lower elevations (*12*). In Cuba, a mining company has initiated plantations with *Eucalyptus saligna* Sm. with results which so far have been very promising - far more than had been initially expected. The original forest was very degraded and practically without commercial value. The latest plantations, however, have been initiated on

ploughed savanna soils and apparently with similar success. Initially the reforestation scheme was aimed to demonstrate the good faith of the company in forest conservation since large quantities of pine (*Pinus tropicalis)* were being cut for mine timber. Actually, besides fulfilling legal obligations, it appears that the plantations are also an economic success. Growth is amazingly fast and some of the best trees measure 90 feet in height (27 meters) and a diameter at breast height of 14 inches (36 centimeters) after only 5 years. Some of the trees are already in service in the mine, having been previously treated with preservatives to build up resistance against fungus. The ecological conditions make the zone fit into the tropical dry formation of Holdridge's climatic scheme (*51*), with a mean annual temperature of approximately 25°C and annual precipitation of 1,600 mm. Many other species have been investigated as to their ability to grow under similar conditions (*63, 27, 3*).

Advantages and Disadvantages of the Clearfelling Method

Among the most noticeable drawbacks that have been denounced for this method is the radial ecological change involved. The soil is exposed and, without its protective cover, becomes, highly susceptible to degradation. That is why it should never remain exposed for a long time. Sandy soils leach very easily while clayey soils have a tendency to become compact and hard with resulting drainage troubles. A short exposure, however, is not dangerous. That is one reason why many tropical soil scientists defend the so called "primitive" agricultural methods, where short rotations at the expense of the forest are involved. When sprouts are allowed to develop and weeds quickly cover the abandoned field, protection is effectively secured.

Another disadvantage is, that since most of the successes have been obtained with exotic species in pure plantations, there is a danger of insect and disease spread (*73, 59*). So far, teak and *Eucalyptus* spp. have apparently been resistant to any harmful effects of such treatments but other plantations have shown some symptoms. Attacks of a fungus (*Pestallozia*) and insects have been reported in okoume (*Aucoumea klaineana* Pierre) planted in Africa (15). Among the Meliaceae, the shoot borer (*Hypsipula grandella*) has caused extensive damage (*50, 63*). For this reason, wide spacing is often used in the taungya system, with an aim of creating a mixed forest composed of a considerable proportion of valuable planted trees intermingled with trees of natural origin (*54*). This certainly appears to be much less expensive than keeping all the natural vegetation in check as is often practiced. Some of the United Fruit plantations in Central America have been kept cleaned. Furthermore, good form can be economically achieved by this lateral shade. Normally, under the regular system of planting, the number of trees would have to be reduced in closely spaced plantations by thinning.

The idea of establishing mixed plantations with one or two species has been advocated by some technicians, but experience is lacking on the subject. In Cuba, a small area was planted with a mixture of teak, majagua (*Hibiscus tiliaceus* L.), and local mahogany (*Swietenia mahagoni* Jacq.). After several years a few specimens of teak and majagua remained in good condition: mahogany, however, because of its slower growth, was being wholly suppressed.

If there is no reasonably good market for products from the felled original forest and no demand for temporary agricultural use of the land, the initial costs of the method will likely become prohibitive. Still, assuming that these conditions can be solved as in the Belgian Congo, there remains the difficulty of controlling the native agricultural practices as well as ensuring careful handling of the planting stock. In Trinidad only certain crops are allowed and only for a very limited time (*31*); a regular contract is usually drawn up and many other precautions are taken.

The system of land tenure appears to be a fundamental factor in making "taungya" work. How it would succeed in other countries where patterns of land tenure are different remains to be seen. In Latin America there is already a complicated problem caused by the so-called "conuqueros", "parásitos" or "precaristas" (The English equivalent would be "squatters"). The name changes in the different countries but the people involved are essentially the same. They practice shifting agriculture on land which is not their own. In fact they are protected by different laws. It is difficult to predict how the taungya system would be received, under such conditions. Displacement of rural people has always proven to be a delicate problem since economic, social and political factors are involved. This does not mean that the system is bound to fail. Grouping these "wandering farmers" or "squatters" into organized communities or cooperatives with a definite working plan might be the solution to the problem and taungya might be the tool with which to accomplish this long desired objective.

A definite limiting factor of this system is the choice of species. The foregoing experiences show that they must be fast growing, light demanding, and of course, valuable. The first two conditions are essential because suppression by the natural incoming vegetation should never be allowed and the cost of cleaning should be kept to a minimum.

Caring for Natural Regeneration after Clearfelling

With increasing silvicultural knowledge, it becomes gradually more evident that the natural "invaders" coming in after clearfelling have so far received insufficient attention. This is rapidly changing and the new situation may be attributed mostly to the increasing market for the so-called soft hardwoods however perishable. One example is furnished by balsa *(Ochroma lagopus* Sw). formerly considered a weed but now often prized when it appears in abandoned fields. In Perú, extensive natural clearings are made each year by the changing courses of the rivers. Different species of cetico (*Cecropia* spp.) establish themselves readily on these open lands. They are being seriously considered as a source of pulpwood as they can be harvested after only about 4 years (*75*). This may lead to silvicultural system intended to prepare land for this crop. The genus is well represented in all tropical American countries, where it is ussually called yagrumo, guarumo, embauba, etc. All its species are aggressive, intolerant, and very fast growing.

In Puerto Rico, a valuable tree (*Tabebuia pallida* Miers) is able to establish itself on poor degraded soils even when covered with grass, certainly a limiting factor for many other species. The management of this species has shown much promise (*76*).

Finally in Costa Rica and other Central American countries, a good timber tree (*Cordia alliodora* R & P Cham) appears readily on cleared forest land even after pastures have been established. Many land owners do actually appreciate this valuable invader and when releasing their grass from brush, they carefully avoid removal of that species. It has been shown that a few silvicultural operations are able to return high yields and profits (*67*). No clearfelling is done at present for the definite purpose of regenerating *Cordia alliodora* but rather for establishing pastures. However, this situation may reverse with the increasing value of the timber of this species.

It may be stated in conclusion that clearfelling appears to be a very promising system when conditions are favorable, and good control can be achieved in all stages of stand development. The fact that only intolerant fast growing species can be grown properly by this method limits its use to a considerable extent. However, some of the valuable timber species actually have these characteristics; the demand for others is increasing because of new markets. Early production of clear wood that can be harvested under favorable

economic conditions is becoming very attractive; the clearfelling method appears to be a good silvicultural tool to achieve that aim.

Regeneration Through Artificial Enrichment of the Forest in Strips

This system, most popular in Africa especially in the French colonies, consists essentially in opening strips of variable width and planting nursery grown seedlings or sowing seed of valuable species that are adapted to their new environment.

The system aims at several goals. Instead of clearfelling the forest, only strips are cut through it. Thus, labor is saved. Natural environment is also maintained to a better degree and finally, and important from the silvicultural angle, there is lateral shade and overhead light to stimulate straight growth with few lateral branches. The method indeed looks satisfactory if given only theoretical considerations. Practice, however, shows serious limitations and even though some of the results are promising, many species have not succeeded in fulfilling the hopes. Here too it seems essential to first study the ecological habits of the introduced species. The condition of the original forest is also important since different results were obtained depending on whether it was low and secondary or high and primary. Finally, serious consideration should be given to the economics of the system, especially in relation to the labor necessary to open and clean the strips.

Spacing varies in the different zones where the system has been practiced. In the Gold Coast, the strips were 1 chain (20 meters) apart and 6 feet (1.8 meters) wide. Nursery grown species are stripped of their leaves and planted when 3-5 feet tall (0.90-1.50 meters) at a distance of 33 feet (10 meters) within the strip (4). However, it was later necessary to clean the strips to avoid continuous encroachments of the nearby forest, with considerable increase in costs. In the Ivory Coast, the strips, originally set at 33 feet (10 meters), were later increased to 82 feet (25 meters) to avoid costly cleanings (*17*). Similar problems were found by the Fays and Huygen (*43*) in the Belgian Congo. They suggest that in order to avoid excessive cleaning costs, only plots of 13 x 13 feet (4 x 4 meters) should be opened every 33 feet (10 meters) along the strips with one plant for every square meter within the plot. All species dealt with were rather intolerant, that is light demanding and suffering from competition of adjoining trees. The importance of adequate light and lateral shade is well known in tropical silviculture. Wadsworth (*78, 79*) drew the conclusion that upon this balance depended the activity of destructive vines and other noxious species that needed plenty of light. He suggested that any opening of the forest must be kept within certain limits and suggests that 60 percent of shade is sufficient for the trees to keep their good form and also to avoid excessive activity of vines. In some forests of Puerto Rico these openings can be made by harvesting some of the trees used for posts. In this manner the initial preparation costs can be reduced to 30 percent because of the value of this crop. The demands for lateral shade may be so specific in some cases that Dawkins (*35*) reports a case in Uganda where nurse trees of *Cassia siamea* Lamb. and *Eucalyptus* spp. were planted to provide lateral shade for a plantation of *Chlorophora excelsa* (Welw.) Benth.

Perhaps the most ardent defender of this system is the well known tropical forester A. M. Aubréville, who in a long series of papers (*10, 14, 15*) reports on the successes attained and some of the handicaps encountered. Some of the experiences date back 20 years. The conclusions that can be reached after studying Aubréville's observations indicate that there are great variations according to the regions and the different species (*36*). The most successful trials indicate that the most suitable species for this method are also the most intolerant, although generally not to a degree to permit pure plantations

without restrictions. African mahogany (*Khaya senegalensis* A. Juss and other *Khaya* spp.) and okoumé (*Aucoumea klaineana* Pierre) were particularly successful. However, it was never possible to avoid cleaning of natural vegetation that came along the open strip, as well as the encrouchment of the lateral forest, trying to close the gap. Even after 20 years, some of the trees needed cleaning in a plantation where 33-foot (10 meters) strips were opened every 66 feet (20 meters), with trees planted every 16 feet (5 meters) within the strip. A fungus (*Pestallozia*) and some insect damage was also reported although never reaching an alarming stage. The plantations of *Chlorophora excelxa* (Welw.) Benth were also attacked by another insect, *Phytolina lata* (*46*).

The costs of the strip plantations have been calculated in different regions. Le Ray (*60*) reports 136 man-days per hectare (55 man-days per acre) after 5 years, but Bellouard (*25*)lists only 47 and 57 man-days per hectare (19 and 23 per acre) for two 15-year old plantations where 243 and 221 trees respectively were left per hectare (98 and 89 per acre). These experiences came from different African regions.

There is one point of mutual agreement among silviculturists: the possibilities of success are greater when the forest to be treated is of medium height. When primary with high trees, the canopy is difficult to control (*9*, *65*, *25*). Wilten (*82*) suggests the previous girdling of all emergent trees. Since secondary forests are usually found close to population centers, labor is handy and there are good market prospects for some of the products from the strip openings and further thinnings. (See Fig. 1, p. 60)

In tropical America, the United Fruit Co. and some Mexican lumber companies have established some strip plantations in Honduras and Northern Yucatán Península respectively. The species used were mostly cedro (*Cedrela mexicana* L.) and broadleaf mahogany (*Swietenia macrophylla* King). It is premature to judge the value of this system before studying the technical results and the costs. Apparently, the problems of competition from the adjoining vegetation have induced high maintenance costs.

Direct Seeding and Its Variations

An important variation of the system involves direct seeding in the opened strips instead of planting nursery grown stock. In Africa this has been practiced with okoumé (*Aucoumea klaineana* Pierre) (*60*). It is important to seed speedily once the seed has been collected since viability is of very short duration lasting about 3 weeks.

In Mexico the system is extensively practiced with Spanish cedar (*Cedrela mexicana* L.) on the rather dry calcareous flats north of the Yucatán Península. Instead of strips, abandoned logging roads are seeded. After 2 years the seedlings looked very thrifty. At that time the damages of the well known shoot borer (*Hypsipyla grandella*) were insignificant. According to local foresters, some 20,000 ha. (50,000 acres) have been reforested by this method. Since the seed of this species also looses its viability shortly after ripening, it was important to store the seed under cold temperature after collecting in February or April so that it can be sown after the rainy season starts in June. On these secondary logging roads where tractors and trucks had passed, the mineral soil was exposed and ready to receive the seed broadcast by a worker. The Mexican foresters claim that this system has reduced the cost of reforestation by 50 times per hectare if compared to usual methods of planting with nursery-grown stock on cleared strips through the forests. The density of regeneration is such that it soon becomes necessary to thin the saplings. By direct seeding there is no need for nurseries and costly field planting. However, a great quantity of seed is necessary for these large areas. It must be conveniently stored in accessible cold places. The difficulty in obtaining the seed, especially in relation with labor must also be taken into

account. All these factors however, should be capably handled with a minimum of investment by efficient organization. The idea to store seed and then broadcast it when the rains begin on places where mineral soil has been exposed, may possibly appear to be a very simple one. However, if the Mexican experience can be applied in other countries and with other species the practice could prove of great significance to tropical forestry. It might be interesting to note that the silviculture of *Cedrela* had probably received more attention in tropical America than any other species without, so far, solving the problem of satisfactory regeneration. (See Fig. 2 p. 61) The Mexican scheme appears to fit very satisfactorily with current methods of logging in regions where the forest is dry (or tropophyllous or deciduous). A well marked dry season in these regions limits lumber exploitation to a few months and implies the construction of provisional logging roads. At any rate the Mexican method has in its favor the very low costs; it would be very interesting to have other countries experiment on the same problem.

Regeneration Through the Shelterwood System

Many of those ecologists who have studied succession in tropical forests have long known that it is possible to induce regeneration under the natural forest shelter. Yet his observation has only recently been applied in silvicultural practice. The tropical shelterwood system was evolved and is now very much in favor (*70*, *62*, *39*, *71*). Not only is regeneration assured but the young trees in the sapling stage seem to grow well later if release from competing vegetation is skillfully accomplished.

Essentially a natural process that would occur without man's intervention is followed but a gain in time and selection of commercial species is aimed at. That is why the word "refining" has been used to render the idea of conversion of a heterogeneous forest with most species of little value, into a stand of fewer species of much higher value (*37*).

The Different Phases of the Shelterwood System

Two main operations are usually involved in the process of refining the stands: (a) seed cutting aimed to favor good reproduction, and (b) removal cuttings to favor the growth of valuable seedlings and saplings until all the shelter is eliminated. Both operations can merge into a single one in some especially favorable cases which will be considered first.

The Refining of the Dipterocarp Forest and its Repercussion in Tropical America

The particular nature of these forests, rather rich in valuable species, enables the achievement of their refinement in what may be considered the simplest form of the shelterwood system in the tropics. Yet even under the prevailing favorable conditions this scientific approach is rather recent and strangely enough, the result of what was initially considered to be a destructive practice. In effect, it was felt that the forest would not survive the damage resulting when the primitive methods of hauling timber with buffaloes were replaced by the highlead logging method using modern machinery, and involving the harvest of a considerable number of trees per acre. However, very a satisfactory amount of seedling and saplings, often 600 or more per acre (1,500 per ha.) were counted 1 year after such a logging in Malaya (80). Further investigations revealed that, where windthrow damage had taken place or intensive logging had been carried out under the Japanese occupation, the forest was also behaving favorably and a new generation was coming up in dense pole stands under the slash. At this point one might gain the impression that under modern logging methods, clearfelling is done and regeneration secured.

This is however, not the case; clearfelling is in fact criticized, because the land is left open to the invasion of *Imperata* grass, which later proves to be very hard to eliminate (*83*). Actually, even in the richest Dipterocarp forest, the logging of the commercial trees takes only a part of the total standing trees, leaving a considerable amount of valueless trees, either of non-commercial species or too poor in form to be harvested. Evidently the dense reproduction normally present under the forest was just waiting for some kind of liberation. The removal of a large amount of the cover gives them that chance and also favors more germination and the establishment of new valuable regeneration. It is true that such reproduction includes again a great number of different species many of which may be of low value. At this young stage however, an easy elimination of undersirable species can be early achieved under very economical conditions (*21, 81*).

The shelterwood system is now widely practiced in Malaya and logging permits are granted with no restrictions on the amount of timber to be harvested on government land. In addition, the permit specified that the remaining noncommercial trees be either removed or killed very shortly after logging. It is, however, important that previous countings show a good stocking of advanced reproduction before logging is allowed, and it may sometimes be necessary to wait for good seed years. However, annual establishment of regeneration appears to be the rule rather than the exception. The sudden opening will certainly stimulate a considerable increase in the activity of climbers and, as a result, a kind of mat may be formed over the new canopy of small trees. It seems, however, that the saplings are not too seriously affected and will eventually push through, an important phenomenon which cannot be easily matched in other tropical countries after similar operations. Cleanings of course become necessary in due time and are conducted at regular intervals during subsequent years in addition to the first thinning.

Possibly one of the most favorable features of the Dipterocarp forest is the presence of good advanced reproduction under the natural shelter. This condition has been described for other tropical forests but is only common in rather undisturbed forests or special associations like swamp forests (*39, 62, 24, 40, 68*). It is most frequently encountered in stands where the trees bear heavy seeds as in the *Mora* forests of Trinidad, the Guianas, Venezuela, Colombia and Panamá, in *Prioria copaifera* Gris (20), *Carapa guianesis* Aubl. *Virola* spp., all of them economically important. They are usually found in rather pure associations or account for a large proportion of the components of the stand, quite similar to the percentage of the Dipterocarp species of the forests of the tropical Far East. There is no information on the application of the shelterwood system to regenerate these American species but it is known that clearfelling will not result in desirable reproduction even if a few seedlings or saplings are present. Weed species will come in and outgrow them.

Seed Cuttings

The favorable conditions of the Dipterocarp forests may be rated as exceptional if compared with other countries (*32*). Most of the forests that are sufficiently accessible to justify intensive silvicultural operations are often secondary and usually degraded. The most valuable species have been exploited and many undersirable species have reached great size. On the other hand, the presence of nearby population centers and the relative accessibility of these forests means that usually good local markets can be found for fuelwood, charcoal and small sized timber. This is an important advantage when improvement or intermediate cuttings are conducted because it may lower the cost of some of the initial operations or even render some profit (*18, 77, 53*). Because of the degraded conditions, good natural regeneration is commonly lacking. Seed trees of valuable species may not be present in sufficient quantities

in the forest. As a result of poor cutting practices, fire, and grazing, many weed species have invaded the open stand and dense underbrush may cover the ground. This is certainly common in many forests of India, Africa, and much of tropical America, especially around population centers. If the seed source is wholly inadequate it is evident that the shelterwood system cannot be utilized and must be replaced by some other method of regeneration involving artificial restocking (*71*). There is, however, considerable evidence that even with few seed trees of good species, good regeneration may come in after the forest has been subjected to some kind of intervention, often much to the surprise of the forester (*49*). In tropical America this is often the case with valuable species like *Cordia alliodora* (R & P) Cham, *Cedrela mexicana* L., *Swietenia macrophylla*, King., *Astronium graveolens* Jacq., *Bombacopsis quinatum* and others. They have winged seeds and are rather intolerant. Furthermore, even some valuable tolerant species with wingless or heavy seeds like those belonging to the family Lauraceae will also appear in the regeneration in spite of the absence of nearby seed trees. This is evidently a result of the activity of birds and bats (*40*).

Thus the forester's problem becomes one of how to act in order to imitate or even improve these natural processes and to apply the technique over a larger area under the most favorable economic conditions. This can often be achieved with an opening of the stand but it is important to consider the intensity of removal, the kind of trees chosen, and the methods of removal.

In Nigeria it was found that some initial openings of the stands definitely favored regeneration as well as the growth of seedlings already present. However, the degree of opening had a marked effect on the kind of regeneration obtained. With light cuttings, a great number of tolerant species appeared which later had a hard time progressing. On the other hand, too heavy openings favored the intolerant species as well as a large amount of climbers and other weeds. Because the regeneration desired was of both tolerant and intolerant species, it was decided that a small opening in the first year followed by large openings later should be the right sequence. At this rate, the tolerant species will establish themselves successfully and achieve some resistance against later competition with intolerant neighbors. These operations were only possible when the forest had a normal structure, that is, a good proportion of trees occupying the different levels regardless of whether they were valuable or not. If too many overmature trees were present or the oldest trees were only in the pole stage, satisfactory openings could not be regulated. The presence of a reasonable number of seed trees was also necessary (*72*).

In Trinidad some spectacular successes have been achieved with the tropical shelterwood system, more so because the forests to be treated were quite degraded (*8 18, 23, 26*). Here, an intensive opening of the stand was made in the lower and intermediate levels, keeping an overhead shelter. Outlets for charcoal burners could economically be utilized to remove those species not merchantable for other purposes. The expected reproduction came in profusely and saplings of eight different valuable species developed very satisfactorily under the shelter. Some of them were of wing-seeded species but others were evidently brought by birds. This emphasizes the importance of leaving trees just to provide shelter and a roosting place for the birds which then leave the seeds in their droppings. One limitation of this system in Trinidad is that natural regeneration can be secured only on sandy soils, but has so far not been obtained on clays.

In British Guiana the same system was practiced in the greenheart (*Ocotea rodiei* (Schomb.) Mez) forest, apparently with excellent results. The lower stratum was completely removed with the exception of greenheart seedlings and saplings. Vines were also cut and some of the upper canopy was opened

according to the needs and conditions of the forest (*19*).

What Trees Should be Removed

The matter of possible harvesting of trees by these seed cuttings, leads to the important consideration of which trees or other vegetation should be selected for removal (*77*) and at what time during the entire operation.

There is general agreement among tropical silviculturists that all climbers should always be removed whenever any cutting is made. Climbers are most troublesome and so far as known, their activity is always in opposition to the best production of timber (*37*). Their activity will increase when a stand is opened and their growth is extremely fast. It is very important to remove them in the early stages of the refining process otherwise they may encroach on different adjoining trees and tie them together, thus rendering later felling operations difficult.

In addition to climbers, the trees usually fall into the following categories:

1. Trees of small size. Most of them will never pass a certain level and usually develop poor form and are rarely of economic importance. Together with overtopped large trees they occupy the lower levels in the structure of the forest and are the first to be eliminated.
2. Dead trees. If they can be sold they should be removed regardless of the fact that ability to cast shade is minimal. Their presence is not really a nuisance except that they favor the encroachment of climbers.
3. Overmature trees. They occupy considerable space and must sooner or later be removed; such removal must be timed and conducted carefully.
4. Immature trees of poor form or undesirable species that reach the upper canopy.
5. Mature trees of undesirable species or poor form.
6. Mature trees of desirable species and good form.

As can be seen there is considerable latitude in the selection of trees which are to be removed at an early stage so that optimum degree of opening of the stand can easily be achieved. Harvesting of some commercial trees, which is certainly an attractive possibility, may even be possible. However, it should be clearly understood that such opportunities should not divert attention from the primary objective of securing adequate regeneration of good species. Too often the allure of an early financial return has ruined further chances for reproduction. The overall policy should always be the removal of all undesirable species first leaving all the valuable trees for seed source. Only in the case of a forest with abundant seed trees of good species is there likely to be a possibility of doing some harvesting of timber.

Where to Concentrate Cuttings

The experiences in Africa and Trinidad also indicate that most of the operations should concentrate at the intermediate levels in the forest, leaving provisionally an overhead shelter.

The question of removal of the ground cover or underbrush is another subject which is apparently not settled. The main idea is of course to secure an abundance of seed and a good seed bed (43). In most places, however the initial germination is good without need of any noticeable special site treatment. Actually the serious mortality really takes place during the later development of the seedlings, which then require considerable assistance. The good reproduction usually found under undisturbed forest is further proof that germination will take place under normal ground cover.

It has already been pointed out that in the Dipterocarp forest no underbrush removal is required. Investigations in other regions, however, show very desirable results from preparation of good seed beds. For example,

Jacob (*55*) has described a situation in Assam, India, where an attempt was made to compensate for the paucity of desirable seed trees by thorough clearing of the ground. This was combined with the removal of most of the trees of the lower and middle levels of the stands in a radius of 20-30 feet (6-9 meters) around the seed trees. The regeneration secured was good but because the distances between seed trees were sometimes large, further silvicultural operations were rather cumbersome and the whole lacked unity. Some of these openings later attracted elephants, buffaloes, and other animals which caused extensive damage, mostly by trampling. The system was therefore revised in favor of a less severe initial cutting followed by more gradual openings at later stages.

In South India, the removal of the underbrush was not even enough to induce good reproduction of such a valuable species as *Dysoxylum malabaricum* Bedd. Instead other less wanted species were obtained. Only after extreme measures were taken like raking the soil just before the seeds fell, frequent weeding or direct seeding seeds coated with red lead to prevent them from being destroyed by vermin, was the desired reproduction successfully established (*66*). This appears to be exceedingly expensive at least if used in other regions where labor is not as cheap as in India.

In conclusion, it appears that removal of the ground cover and the preparation of the seed bed are necessary in some situations but not essential in others. A good amount of underbrush removal and even some disturbance on the soil is achieved regardless of intent mostly by trampling when the seed cuttings take place (*57*).

Removal Cuttings

Once adequate regeneration has been secured, the canopy is gradually removed. The selection of the species which must be removed has already been discussed but in the removal cuttings the value of individual trees is far less important than the quality of the shelter they provide for the new crop. The method of removing the older trees is also an important consideration.

While the canopy is gradually removed the seedlings and saplings demand continuous care to ensure their proper development (*78, 79*). Too rapid removal of the shelter will favor climbers and the establishment of weed species while the presence of a dense canopy will hamper the good growth of the saplings. In Malaya complete removal of the canopy is achieved in only 2 to 3 years but intensive cleaning operations are later necessary to keep the growing crop free of climbers and other weeks. In other places a period of 5 or more years may elapse before the new crop can be left on its own without any shelter (*72*).

It seems impossible to arrive at any kind of generalization concerning the number of removal cuttings and the length of the period over which they are extended. The many variations in local conditions prohibit such generalization. The best criterion to be used is based on frequent observations and countings to determine the conditions of the new crop. Whenever an opening in the canopy is made, it is sound practice to accompany it by a good cleaning of the young crop trees. Again, emphasis should be placed on control of climbers.

Silvicides and Girdling in the Shelterwood System

The recent introduction of the use of silvicides in tropical forestry appears to be extremely useful and widens considerably the practice of economic silviculture. The shelterwood system seems to be especially suited to their use. The removal of unmerchantable trees with short boles and large crown is expensive if they are to be felled and girdling often proves to be ineffective in killing such trees. If the tree is felled the large amount of debris may not only damage the reproduction or advanced growth but may also provide an

excellent framework for climbers. In Nigeria no good method of slash disposal could be found to counteract this effect (*72*). However if poisoning is substituted for felling, the results are highly encouraging. The branches break off when the rest of the tree finally falls.

Poisoning has the additional advantage of opening the canopy quite gradually, thus avoiding any sudden entrance of strong light. This is very important because it checks climbers to some extent and is usually best suited to the requirements of the reproduction. In fact, a similar effect is usually sought in nurseries when the shade is gradually removed over seed beds and planting stock.

There seems to be no point in girdling or poisoning small trees unless extremely vigorous sprouts might occur and hamper the development of the crop. However, according to Barnard (*21*), poisoning should be applied to climbers. He suggests dampening the cut end of the climber in a 1 lb. per gallon solution of sodium arsenite in order to reduce coppicing.

The practice of girdling *Cecropia peltata* L., an American pioneer species, whenever openings are made, has proven very effective in Puerto Rico. It is possible that this species might be useful as a nurse tree because of its rapid growth and the ease with which it can be eliminated by girdling. Observation of many sequences of natural successions in tropical America certainly confirms the belief that *Cecropia* spp. offer excellent shelter for the early development of many valuable species.

With larger trees, poisoning is usually the practice. In Nigeria, sodium arsenite proved to be highly effective (*72*). In Malaya, both girdling and poisoning are widely practiced. However, some rather disastrous effects to animals have been reported when sodium arsenite was used because of its high toxicity (*5*). Its replacement by less toxic compounds will probably overcome these difficulties.

Especially large trees or those of certain species are sometimes difficult to poison effectively — Some species are inherently very resistant to poisoning while others have some peculiarity of bole form such as fluted trunk, strong high buttress, etc., that makes them almost impossible to kill easily. Jacob (*55*) reported that large *Ficus* trees recovered 1 year after poisoning even if they showed signs of distress. However, it is quite probable that some methods will eventually be developed to meet that challenge.

Meanwhile, considerable improvement can be achieved by using the best poisoning technique at the right time and under the most economical conditions. Barnard (*22*) after reviewing the poisoning methods used in the shelterwood system in Nigeria concluded that many cumbersome operations were practiced and could well be replaced by more effective and cheaper methods. Instead of difficult climbing of trees with large buttresses in order to poison them above, he suggested frill girdling and poisoning on the buttress itself at the most convenient height. Furthermore, this killing should be done during the rainy season and not at the peak of the dry season when growth is least active.

Advantages and Disadvantages of Shelterwood Cutting over other Regeneration Methods

Advantages

1. The regeneration is achieved without deviating too much from natural processes, especially as compared with the clearfelling method.
2. It is less often necessary to resort to planting than with other systems.
3. There seems to be less liability of attacks of insects and deseases.
4. The soil is always kept under some kind of a vegetative protective cover.
5. The system can be used with both tolerant and relatively intolerant species.
6. The new crop develops good form during the initial years.
7. The control of shade prevents the entrance of undersirable pioneer species

and to a certain extent, restrains the activity of climbers; fewer cleanings are needed.

8. There is good protection against damaging atmospheric agencies.
9. The system may be used with heavy seeded species.
10. The system appears to be cheaper than any other.

Disadvantages

1. The system cannot be used with very intolerant species.
2. Harvesting of valuable species may not always be possible because when only a few are present they are usually needed for seed source and once the regeneration is established, their removal through logging may be damaging to the new crop. This inconvenience becomes particularly important when the second rotation eventually arrives. Evidently a large number of trees will have to be harvested this time. However, it is quite possible that at that stage the forest will behave like the Dipterocarps earlier described; the large amount of good seed trees will then ensure a very good regeneration and logging can be done once the advance growth is established. These are, however, merely guesses because this second rotation has nowhere been completed in the tropics.
3. It cannot be used in stands where seed trees of valuable species are absent or very rare. Dispersal of seeds by birds and bats may possibly counteract this fact but only to a small extent.
4. The method requires some skill and good control over all operations involved.
5. There are even some tolerant species that cannot be regenerated economically under this method. This may be due to our present lack of knowledge of the silvics of these tropical species.

The Results so Far Achieved

Reports from different countries where the shelterwood system is practiced are highly encouraging. Many improvements are constantly being made especially with the accumulation of more data on the silvics of various species. In some areas, the shifting from other systems to shelterwood has been reported (*70*, *71*). The recent introduction of silvicides is likely to increase the adoption of this system because their use finds ready application in many of the operations involved in shelterwood cuttings.

The best proof of this is probably to be found in the fact that many countries, notably Nigeria, Belgian Congo, Malaya, Trinidad, and Costa Rica are expanding their programs of refining the heterogenous forest through this method. In tropical America, promising results have been obtained in Trinidad, British Guiana, and more recently in Costa Rica (*53*) where *Astronium graveolens* was regenerated, and Perú where *Cedrelinga catenaeformis* was the species involved (*28*). The results experienced in all these countries indicate that a bright future may be visualized for the shelterwood system.

SUMMARY

Regeneration methods in tropical lowland forests have lately received a great deal of attention. The present study intends to review and discuss the experience acquired so as to improve silvicultural programs for the future.

In order to transform the heterogeneous forest with only a few valuable species into stands of better composition and higher values, three systems are currently practiced:

1. Clearcutting followed by immediate planting of valuable species. It can be done satisfactorily only with light demanding, fast growing, naturally insect and disease resistant species, on accessible lands and on ecologically suitable sites. The best utilization of

the forest to be cleared and the temporary use of the soil for agriculture ("taungya" system) appear economically very desirable, but require a good control over all operations involved.

2. The artificial enrichment of the forest by underplanting in strips. Best results have been achieved in secondary forests close to settlements. Broadcast seeding on abandoned lumber roads, shortly after the beginning of the rainy season, as practiced in Yucatán, México, appears a promising alternative.
3. The shelterwood system. It has been used most successfully when the original structure of the forest has not been much modified, when seed trees are present in adequate quantities and when rather tolerant species are to be regenerated.

The usual operations involved in securing a good reproduction require opening of the stand particularly at its intermediate levels (see cuttings) and the final complete removal of the canopy at a later stage.

Girdling and poisoning of undersirable species appear to be very effective practices to complement harvesting and the gradual elimination of the canopy and favor the best development of the new growth.

The system is favored by an increasing number of tropical silviculturists.

Report of an Ecological Survey of the Republic of Panama

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INTRODUCTION

In response to a request from the Government of the Republic of Panama directed to the Technical Cooperation Program of the Organization of American States, an ecological reconnaissance of all Panama was made in the Spring of 1955. Considering the size of Panama and the fact that the two technicians had only one month available for the work, mapping was restricted to delineation of the life zones of forest formations of the country. However, this was the goal of the project and the following notes describe these areas and their relation to agricultural and forestry uses.

Such an ecological survey is considered to be one of the basic steps in planning national uses of a nation's resources. At the same time an attempt was made to sketch out the most promising areas for concentration of extension work, future surveys and forestry development. The experiences, both favorable and unfavorable, of other countries of the region in utilization of the renewable resources in the various life zones have been drawn upon as a guide for Panama, where the population is still of light density.

In order to develop and maintain a satisfactory level of living, man must maintain an ecological balance with his environment. If he works in harmony with natural conditions, he can develop an efficient and permanent use of renewable resources which will provide him with all the necessary benefits of an abundant life. If he work against nature, the results will be a waste of resources, giving rise to poverty and many economic and social problems. Fortunately, Panama is still in a favorable position to guide its own development and, if it, so wishes, may develop a strong, sound economy and a strong nation.

Before going on to further discussions, we wish to express our sincere appreciation to the many organizations and individuals who so willingly cooperated in many ways to facilitate our work. The organization of SICAP, directed by Mr. Benjamin Birdsall, made the arrangements for all trips within the country and provided for transportation and other expenses of the survey. Dr. Solis and Mr. Lawrence Cummings of SICAP took care of specific trip arrangements and the latter accompanied us on most of the trips. Mr. Guzmán and other in the main office assisted us in collection of data and SICAP agents in the field helped us a great deal on local arrangements.

The Chiriquí land Co kindly furnished motor car transport in Chiriquí Province. Also Mr. Max Arosemena and his organization, Instituto de Fomento Económico were extremely helpful in arranging trips just to the east of Panama City. Diputado Pablo Oten of Darién helped us very much in the region of El Real. To all these and the many other individuals two numerous to mention, we wish to express our appreciation for their assitance in making our surveys more efficient and pleasant.

General Geographical Facts of Panama

The Republic of Panamá comprises the southeastern extension of what is generally

considered as Central America, bounding with Colombia on the East, Costa Rica on the West and with the Atlantic and Pacific Oceans respectively on its northern and southern coasts. The area of the territory is 29,128 square miles excluding the 553 squares miles of the Canal Zone. The population of the country was listed as 851,900 in 1952, constituting a density of only 29 percent inhabitants per square mile.

In shape, Panamá essentially resembles an irregular and narrow arch, running in a general east-west direction, and varying in width from 30 to about 120 miles. The same orientation applies to the main mountain range which form the backbone of the country with only one appreciable gap in the center in the vicinity of the Panamá Canal. This range reaches a height of a little over 11,000 feet in Volcán Chiriquí or Barú at the western end, but elevations are much less to the east of the Canal. Other minor mountain ranges occur in the Península de Azuero to the South, along the Colombian frontier and bordering the Pacific coast in eastern Darién Province.

Due to the many mountains on such a narrow trip of territory, there is little left for the plains. The largest of these are found on the Pacific side, both in Darién Province, where the biggest rivers occur and in the provinces of Chiriquí, Veraguas, Coclé and Los Santos on the western sides of the country.

Climatic Factors

Temperature

The Republic of Panamá lies wholly within the tropical belt so that all of the lowlands have a mean annual temperature of over 24º centigrade. The highest temperatures occur in the drier areas on the Pacific side of the country.

With increasing altitude, lower temperatures are encountered, which give rise to four significant elevational belts of vegetation. The lowest of these is the tropical belt, ranging from sea-level up to about 600 meters on the Caribbean slopes and up to approximately 700 meters on the Pacific slopes.

The subtropical belt extends from these elevations on up to approximately 1,500 meters above sea-level. The lower montane belt extends from the upper limit of the subtropical belt up to aproximately 2,600 meters above sea level. The major part of this belt is restricted to western Panamá in the Cordillera de Talamanca and the Serranía de Tabasara but small areas do occur in eastern Panamá along the frontier with Colombia. The montane belt is restricted to a few isolated areas on the higher peaks in the Talamanca Range. Although a few subalpine plants may be found on the peak of Volcán Chiriquí, Panamá does not reach the subalpine belt.

The approximate total acreages and percentages of the area of the country by elevational belts is shown in the following table:

	Area in K2	Total Percent of area
Tropical Basal Belt	56,430	76.3
Subtropical Belt	13,800	18.6
Lower Montane Belt	3,530	4.8
Montane Belt	250	0.3
Total	74,010	100.0

Precipitation

Within the elevational belts, differences in annual rainfall give rise to significant changes in natural vegetation and correspondingly in agriculture. These natural divisions which are termed life zones or plant formations are plotted on the map of Panamá on page 94.

Ordinarily, the transition zones where two formations join are not extensive and one line delineates the change from one life zone to another. However, in the Darién region, we found that the total precipitation over considerable areas is very close to 2,000 mm. or 80 inches and the change in precipitation is so gradual that the zones of

transition are extensive enough to warrant separate delineation.

The rainfall on the Caribbean coast and slopes follows the general pattern of the Caribbean area. The trade winds from the northeast and east bring air which is heavily laden with moisture to the land and precipitation is essentially orographic. Heaviest annual precipitation probably occurs in the lower part of the lower montane belt or the upper part of the subtropical belt, at around 1,500 m. elevation. At present, however, there are no meteorological stations at these elevations on the Caribbean slopes to verify this statement.

The air movement from the Caribbean passes to a limited extent over the divide during the rainy season so that the upper parts of the southern and southwestern slopes are definitely influenced by the Caribbean climatic regime. Only in the vicinity of the Canal Zone, where the country is generally low does this Caribbean influence during the wet season extend across the isthmus to the Pacific. This is evident just to the west of the canal and may be observed in the vegetation along the highway from before Chorrera to beyond Capira.

On the Pacific side, the precipitation is predominantly conventional, occurring during the rainy season when the belt of doldrums has moved north from South America to over Panamá. However, there appears to be a strong influence there of winds from the southwest so that wherever parts of the isthmus face the southwest, there is an indication of higher rainfall giving rise to a vegetation similar to that of the Caribbean side.

In general then, the whole Caribbean side is moist to wet whereas the Pacific side is broken into moist or dry subregions. The dry season is long and strong in the dry forest formation on the Pacific. Also, the dry season is more marked in the moist forest formation there than in the corresponding life zone on the Caribbean side.

The driest area observed in Panamá was found on the western side of the Azuero Península.

Close to the Colombian border, there is indication of entrance into a different climatic region which is generally more rainy, and thus, wind directions and mountain barriers do not seem to be as important in influencing rainfall as they are to the west.

Winds

Winds are significant to the Panamanian climate mainly in producing orographic rainfall and accentuating dryness on parts of the Pacific slope, when the stronger trade winds cross the isthmus during the dry season. Fortunately, Panamá lies out of the sweep of the hurricanes which cross the Caribbean sea to the north. However, in connection with storms, local wind currents may cause "blowdowns" which can affect seriously such crops as bananas.

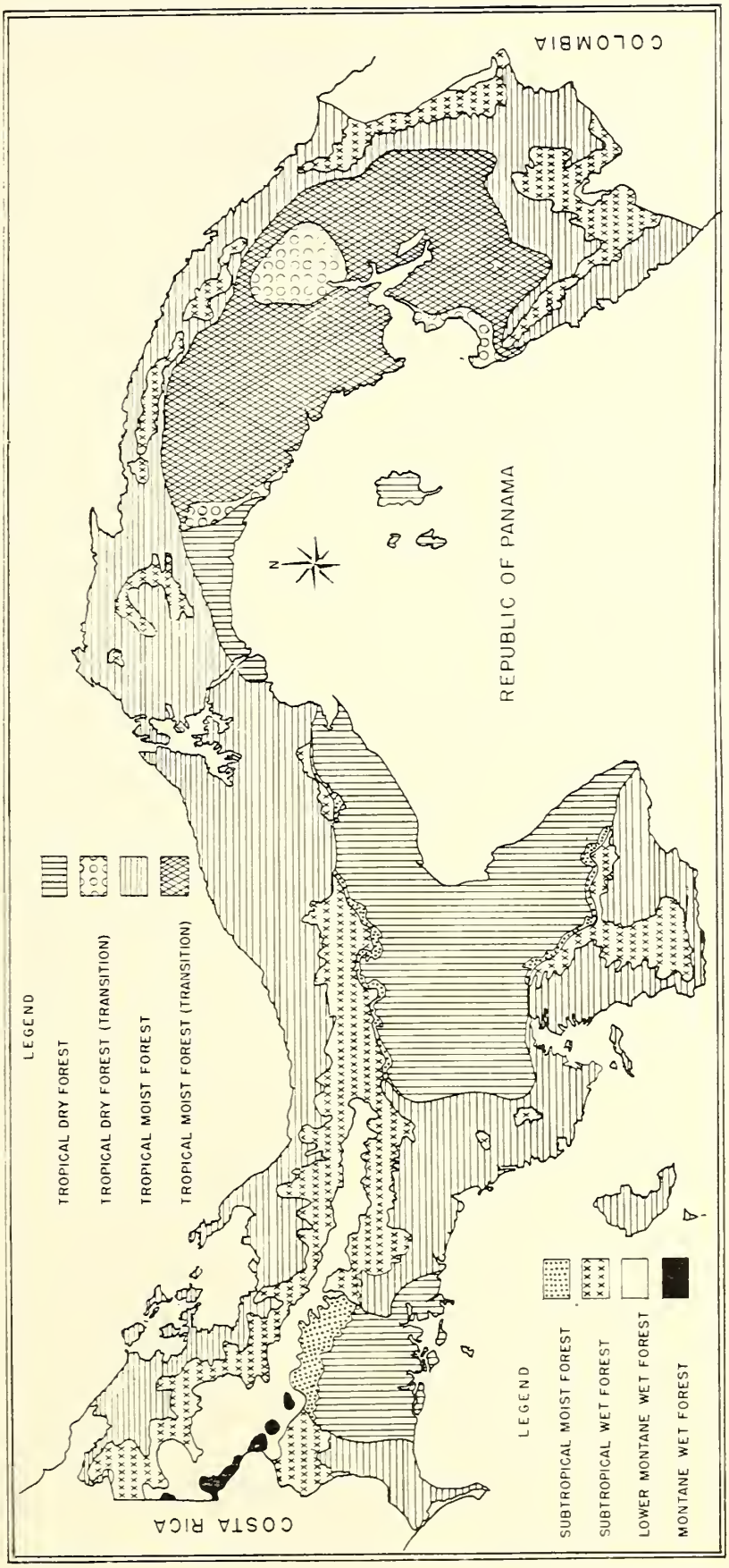
Edaphic Factors

Although the climatic factors of temperature and precipitation determine the pattern of life zones or formations, within each formation, the plant associations, the physiognomy or appearance of the vegetation and the best use which man can make of the areas depend upon the edaphic or soil factors. These factors comprise topography, water table levels, physical condition and chemical composition of the soil.

Topography

Panamá is predominantly a country of low and medium elevation. Only in the western part of the country are to be found appreciable areas in the lower montane and montane belts. As a continuation of the high mountain range of Costa Rica, the Cordillera de Talamanca and the Serranía de Tabasara occur as a high broken mountain range, which attains its highest elevation at 3,470 m. in Volcán Chiriquí.

Most of the subtropical belt comprises rough topography with only very limited areas of flat or gently sloping lands located in the valleys or on the tops of wider ridges.



Plant formation zone - Republic of Panamá

Also, the lower tropical belt which covers the major part of Panamá is predominantly hilly and broken. Within the area of moist forest on the Caribbean side there are numerous narrow alluvial strips along the rivers, but only in the Bocas del Toro Province and in the area just to the west of the Canal, as between Chorrera and Gatun Lake, are there extensive areas of flat or gently sloping lands.

On the Pacific side four significantly important areas of level and gently sloping lands are to be found in the David — Armuelles section, the Coclé-Veraguas-Herrera dry forest areas, a strip running east from Panamá City with a narrower extension up the Río Bayano Valley and lastly, the river valley areas of Darién Province.

High Water Tables and Excessive Drainage

Wherever water tables are high during part or all of the year, the vegetation of such areas is quite distinct from that of adjacent normally drained forest lands. The most extensive of such areas are to be found in the lower river valleys in Darién Province and adjacent to the lagunas in Bocas del Toro Province. Similar associations of limited areas are to be found also along the rivers and coasts in many parts of the country.

Of much less total acreage are the areas of sandy soils and limestone hills where drainage is excessive as reflected in a less luxuriant and more xerophytic vegetation. Examples of such areas may be observed around Patiño in the Darién, on the hills south of Conchita on the Bayano River, and on some of the volcanic outwash areas in Chiriquí Province.

There is still another combination where a hard-pan results in waterlogging during the wet-season and excessive drying out during the dry season, as may be seen in the flat savannas of the Coclé region. However, the savanna areas are also complicated with chemical poverty of the soil which may be due in part to their original composition and in part to long-continued, annual burning.

Physical and Chemical Conditions

Although it is general knowledge, that the physical and chemical conditions of the soil under virgin forest cover may be quite satisfactory or excellent, of special importance to man in relation to his agriculture are those areas which can maintain such conditions for long periods of time following removal of the forest. The areas which come closest to fulfilling these requirements in Panamá are the flat alluvial lands and the areas of recent volcanic soils. Such recent volcanic soils in Panamá are to be found only in extreme western Panamá. There, where flat alluvial lands have been enriched with recent volcanic soil, are located the best agricultural soils of the country. Still there are extensive areas of alluvial soil in other portions of Panamá which can adequately supply the agricultural needs of the country for some time to come.

Stony soils are common in the dry area of Chiriquí Province and extensive areas of low fertility in the dry forest formation are to be found in the vicinity of David, in Coclé and Veraguas and to the east of the Canal. In the moist forest formation, a smaller area of very poor soils giving rise to savanna vegetation may be observed between Chorrera and the coast.

Biotic Factors

Although, ecologists consider under this title the effect of all forms of life on the vegetation, in the present discussion, we will restrict consideration essentially to the major influence of man, together with that of his domestic animals, and of fire which is almost exclusively spread by man.

With a quick glance at the map one can observe the apparent concentration of place names in the tropical dry forest life zone. These were the major areas of settlement in the centuries following the first European colonization of Panamá and very likely had constituted previously the main centers of

aboriginal settlement based on maize culture. This was primarily due to the lesser effort needed to control woody vegetation which competed with cultivated crops or, subsequent to Spanish colonization also with the grasslands established for pasturing livestock. Long continued burning in these dry regions has greatly altered the original forest vegetation and has been conducive to much impoverishment of the soils, especially on the hilly lands.

Within the past century, three other concentrations of population have been developed, one within and adjacent to the Canal Zone traversing the isthmus and the other two connected with banana culture in Bocas del Toro Province and in the Comarca del Baru.

From these various centers of population concentration in both life zones, the expanding population is now moving out into adjacent areas. Man's influence in the rest of the Republic is much lighter and tends to date to be confined to narrow strips along the coast, along the rivers and along the highways which have been developed in recent years. In general, the overall influence of man on the vegetation of Panamá is still quite limited and restricted to certain areas of concentration. Within these, the areas affected by crop cultivation are much less than those where the vegetation has been cleared by man or fire for grazing.

However, the population has now reached numbers where subsequent geometric increase are bound to result in profound changes of the vegetation and natural landscapes of Panamá within the next few generations. The need for planning and the possible results of man's future impact on the natural resources of Panamá are discussed subsequently in the report.

Natural Vegetation of Panamá

The natural vegetation of any area is a response to the climatic and edaphic factors prevailing on the site. Within a biogeographical province, many species of plants may be used as indicators of variations in climate or soils. This is especially important in Panamá where meteorological data is scant and the soils have been little studied. In the present study, observations were confined largely to tree species, which because of their size and major exposure to the climatic elements are considered the best indicators. Where man has made extensive clearings, however, it was found necessary to use smaller elements of the vegetation also, in addition to any scattered trees.

Since this survey was an ecological reconnaissance and time was extremely limited, few collections were made and there was no attempt made to identify all of the tree elements of any given association. Tree lists in many areas were compiled with the main purpose of locating the indicator trees which are of special importance in classifying an area and which permit interpretation not only of climatic and edaphic factors but also of present and potential agricultural use.

The tropical dry forest of Panamá is characterized by the following trees:

Acrocomia sclerocarpa Mart., Palma pacora o Corozo
Albizzia caribaea
Apeiba tibourbou Aubl. Cortezo
Bombacopsis quinatum (Jacq.) Dugand Cedro espino
Bumelia sp. Pino alegre (?)
Calycophyllum candidissimum (Vahl) DC. Madraño
Chlorophora tinctoria (L) Gaud. Mora
Cochlospermum vitifolium (Willd.) Spreng. Poroporo
Diphysa robinioides Benth. Macano
Enterolobium cyclocarpum (Jacq.) Gris. Corotú.
Luehea candida (?) (DC.) Mart.
Pithecolobium saman (Jacq.) Benth
Platimiscium pinnatum (Jacq.) Dugand. Quira.
Prosopis juliflora (Sw.) DC. Aromo
Pseudosamanea guachapele (H.B.K.) Harms
Sciadodendron excelsum Gris. Lagarto
Simarouba glauca DC.

Sterculia apetala (Jacq.) Karst. Panamá
Sweetia panamensis Beth
Tabebuia chrysantha Guayacán
Xylopia frutescens Aubl. Malagueto macho

There are nearly 100 species of trees of all sizes in the association on good soils. Also, we are not listing here many striking trees such as *Ceiba pentandra* Gaertn., ceiba; *Bursera simarouba* (L.) Sarg., carate; and *Didymopanax morototoni* (Aubl.) D. & P. because such species are found also in the Tropical Moist Forest.

On the poorer soils, such as the savanna lands of the Pacific side, the number of species are less, the original forests were composed of trees of lower stature, there are more spiny legumes such as *Prosopis juliflora* (Sw.) DC and *Acacia farnesiana* Willd., and we find, in places, high percentages of fire-resistant species which tolerate poor soils such as *Curatella americana L.* and *Xylopia frutescens* Aubl.

The two associations of poor soils in this life zone are to be found in extensive areas as exemplified in the savannas and the low foothills of Coclé province and around David in the province of Chiriquí.

Along streams or on alluvial flats next to rivers where the water table is high, may be found tree species from the tropical moist forest such as *Anacardium excelsum* (Bert. & Balb.) Skeels, espavé, but these are not able to resist the long drought on the sloping lands.

The above four mentioned dry land associations are the main grouping of plants covering appreciable areas. There are small-area plant associations of scientific interest, but these were not considered of importance in this study. The swamp forests are to be treated in a subsequent part of the report.

The Tropical Moist Forest

The Tropical Moist Forest including the transition zone to the dry forest covers approximately one half of the area of Panamá. We were not able to separate out the West Forest although there are indications along the San Blas coast and farther west that possibly considerable areas may have a rainfall of over 160 inches and belong properly to another formation. However, travel within the Caribbean coastal forest strip is difficult and time did not permit our making extensive trips into the foothills.

The characteristic tree species of the Tropical Moist Forest are listed here as follows:

Anacardium excelsum (Bert. & Balb.) Skeels Espavé
Brosimum spp.
Carapa guianensis Aubl.
Cecropia obtusifolia
Centrolobium patinense (?) Pittier
Coccoloba (?) *tuerckheimii* D. Sm.
Couroupita panamensis
Dipteryx panamensis
Gustavia sp., Membrillo
Iriartea exorrhiza Mart.
Jacaranda copaia (Aubl.) D. Don, Palo de buba
Lecythis sp. Coco
Luehea seemannii Tr. & Pl., Guácimo
Pentaclethra macroloba (Willd.) Kuntze
Theobroma purpureum Pittier, cacao cimarrón
Virola spp.
Warscewiczia coccinea (Vahl) K.

Transition Forests

Ordinarily transition areas between two life zones are narrow and are not mapped separately, but in Darién Province we found such extensive zones of transition that we mapped these out separately. In such transition areas, there is a mixture of the tree species from each formation plus certain species which are typically transition species.

The interesting tree, cuipo, *Cavanillesia platanifolia* H.B.K. is one of the latter. When one crosses the isthmus of Panamá near the Zone, this huge tree is found fairly well restricted to the edges of the moist and dry

forest in a narrow strip. However, in the Darién, this species occurs over a very wide section indicating clearly that this whole area is a transition belt.

The portion of the moist forest which is typed as transition forest contains a much higher percentage of valuable timber species than is ordinarilly found in the moist forest, climatic conditions are also excellent for agricultural use.

Swamp Forests

The swamp forests of Panamá are extensive and especially interesting for potential forest industries because of their composition of one or few species. Such pure stands are rare in the tropics except under special edaphic conditions. Of the various associations the four which are most extensive are the manglares, the alcornoque forests, the cativo forests and the orey forests.

Although there are swamp forests of various sizes scattered all along the coasts of the republic, we carried out the major part of our observations in the Darién and in Bocas del Toro Province, where these associations comprise thousands of hectares. Although the rainfall is considerably higher at Bocas del Toro, the major difference between these areas is the fluctuation in tide levels. On the Caribbean side there is a difference of a litttle over 20 inches between mean high and mean low tide levels whereas in Darién this difference is close to 20 feet.

With this differential in tide levels in the Darién, the effect of the tide are felt far up the rivers, although there the rise of water is due to the damming of the waters by the tide. The approximate point on a river to which the brackish waters reach appears to be marked by the disappearance of red mangrove *(Rhizophora mangle L.)* and the appearance of *Montrichardia arborescens* (L.) Scholt, a tall aroid, which grows on the soft mud of the river banks. The most extensive flooding occurs when the highest tides coincide with periods of heavy rainfall and full rivers.

Mangrove Swamps

In Darién Province, there are several thousand hectares of periodically innundated tidal swamps occupied by pure stands of red mangrove. With the high tides, the salt water moves back readily through the forest which probably accounts for the extensiveness of the red mangrove. At Bocas del Toro, the red mangrove is found on the fringe of the swamp only with black and white mangrove occupying the area towards dry land. In the Darién, these species show up first on the river banks where fresh water from the rivers reduce the salinity.

The stands of red mangrove appear to average around 80 to 90 feet in height with good straight boles and heavy volumes per acre. At the present, they are exploited only for the bark of the tree and this cutting has not been very extensive.

Alcornoque Swamp Forests

Again in the Darién Province, this association covers extensive areas, apparently taking over the area of manglares which have been built up to a higher level. Here there is more firm ground which appears to be above normal tide levels, but which when flooded is covered with brackish water.

The trees run to larger diameters than the red mangrove and are not as tall or as straight. They do in total, however, contain a large quantity of timber in pure one-species stands.

Pterocarpus officinalis Jacq. Stands

This leguminous tree with ribbon buttresses occasionally form pure stands just next to the mangroves in perhaps softer lands and those more inundated with brackish water than the alcornoque forests. At any rate, they are nowhere extensive in Panamá and are not important as commercial forests.

Orey Swamp Forests

In Bocas del Toro Province, nearly pure stands of Orey, *Campnosperma panamensis* Standl. occur extensively on the low lands,

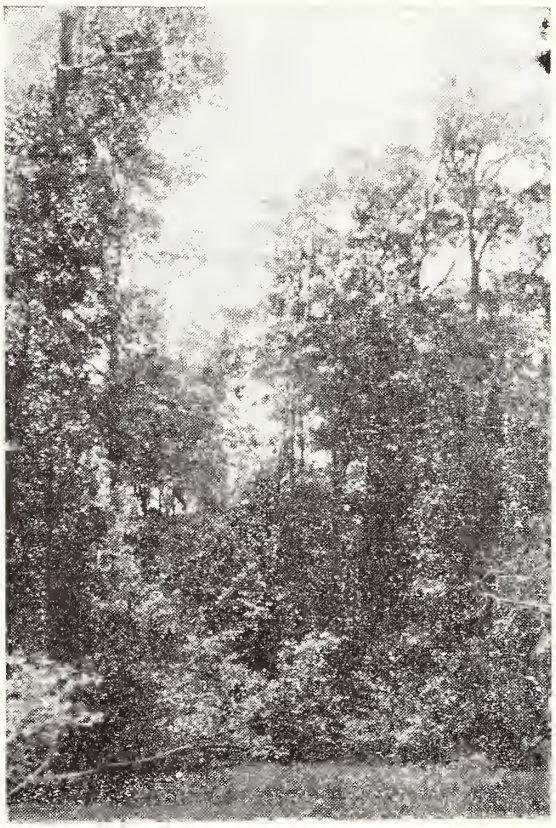


Fig. 1 - Dense stands of red mangrove **(Rhizophora mangle** *L.) in Panamá, reach an average height of 24-27 meters and trunk diameters sometimes above 40 centimeters.*

just above sea-level, of the islands, peninsulas and mainland shores. It appears, that these areas are not actually flooded by the tides but that there is a high water table of brackish water.

The asociation contains a few other small trees in the understory and an occasional large tree of *Symphonia globulifera* L. in or above the canopy. The stand is not too heavy in volume as the trees are mostly in the 10 to 18 inch diameter range and the trees do not appear to go much beyond 60 feet in height.

Cativo Forests

On the flat lands of the Darién extensive areas are found of nearly pure stands of cativo (*Prioria copaifera* Gris.). This tree seems to occur on flats above normal tide levels similar to those of alcornoque, but when inundated are covered with fresh water only. A few other species such as tangáre. *(Carapa guianensis Aubl.)* and *Quararibaea* are mixed with the cativo even where the floods are highest and as the land becomes progressively higher more and more of the species of the normal tropical moist forest appear in the mixture.

Fig. 2. - Dense and valuable stands of cativo **(Prioria copaifera)** *are found in the forests along the rivers of Darién.*

These stands, as described by Lamb, contain heavy volumes per unit area as the cativo is a tall, straight tree of large diameters and occurs in dense stands.

Pachira aquatica Aubl. Swamp Forest

Above the alcornoque forests on the Sambú River, we observed small areas of pure stands of this tree. The association seems to be restricted to soft, unstable soils which are flooded by fresh water only. This association probably fills the role of stabilizing such soils, and then, is replaced by cativo. The trees in the stand are less than 30 feet tall

Fig. 3. - Interior of a mora forest (probably **Mora excelsa** *) in the lower banks of the rivers in Darién. Although the stands have a high volume per unit of area the trees seldom are well formed.*

Fig. 4. - Interior view of a stand of **Pterocarpus officinalis,** *often flooded. The trees are rather of small diameter but have large and thin buttresses.*

with diameters below 8 inches. The association is of no importance for timber.

Manicaria Swamps

In Bocas del Toro Province, we observed fresh water palm swamps which are found also farther west along the Caribbean coast. The *Manicaria* is a large-leaved and short-boled palm. No observations were made within these swamps but in some places it was noted that cedro macho reproduction was beginning to grow up above the palms.

Subtropical Forests

Little time was spent in observations of the vegetation of this belt above the lowland tropics, primarily because they are of much less economic importance than the lowland forests. Where rainfall is high they are, however, extremely important for the regulation of stream flow. Where near to center of population, they attain special importance for park, recreational, or vacation home and hotel areas.

The subtropical moist forest is typified primarily by several species of the Myrtaceae of both the genera *Eugenia* and *Myrcia*. In general, the association is composed of small-leaved species and the natural forests is of little importance for timber. Within this life zone, most of the original forest has been removed for the planting of coffee or other crops.

The subtropical wet forest is a higher denser forest with many Rubiaceae, Melastomaceae, and Lauraceae, *Laplacea*, *Brunellia*, *Inga* spp., *Calophyllum*, *Taonabo*, *Ouratea*, etc. In the Cerro Azul district, we travelled beyond Loma Pelado where the vegetation approaches that of Subtropical Rain Forest. Here was found *Podocarpus*, *Alfaroa* and *Quercus*. As indicated by the tops of the hills, where the vegetation is low and sparse, leaching of the soils due to the high rainfall is very pronounced. Once the higher natural forest is removed on the slopes, the same process of deterioration of the soils will take place. Thus the natural vegetation indicates very clearly that this area is not suited for agriculture.

The lower montane forest of the Chiriquí mountains is characterized by *Persea schiedeana* Nees, *Quercus copeyensis*, *Weinmannia pinnata* L. and *Cedrela tonduzii*. There are several timber species, the trees of large dimensions and the stands heavy. The area makes excellent pasture with kikuyu grass (*Pennisetum clandestinum* Choiv.) but most of the area in this formation is really too steep for agriculture. Both this and the montane forest above, which we did not visit, are important for the regulation of mountain streams.

Future Use of Resources

As mentioned previously, the present population of nearly one million people have made as yet only light inroads on the natural resources of the Republic. This is even more marked in Panamá where a considerable number of people near the Canal Zone derive their income from service and trade operations which do not draw upon the resources of the Republic.

However, the doubling, redoubling and redoubling of the population which will occur within the next century is bound to bring forth tremendous changes and a terrific impact on the natural resources of Panamá. It must be a sobering thought to government leaders to note that with the present plethoria of natural resources, namely, rich lands, excess of valuable timbers, abundant water and wild life that so many families actually continue to exist on a low subsistence level only. Such low level subsistence agriculture destroys potential riches without any benefit to a nation and seems to result only in a rapidly increasing number of additional family units to carry out further destruction on a faster and more extensive scale. Undoubtedly, the people of Panamá and their leaders are faced with a very serious challenge in the use of their available resources. The pattern

of use within the next few decades will determine whether they are to live a rich, happy life in harmony with their environment or to waste their natural wealth and develop another tropical "poor-house" of low-level subsistence only.

Thus, Panamá is faced with two distinct yet related problems, namely, that of raising the existing levels of living of the present population and that of planning future use to maintain and improve on any immediate gains and with a continually increasing population growth. To do that, the people of Panamá must understand thoroughly their renewable resources and how to use them in a manner which will sustain or improve their productivity.

Of the basic resources, the soil which directly or indirectly gives sustenance to plant or animal life, is the most important, Panamá has sufficient level or gently sloping lands of the proper physical and chemical nature to produce the agricultural products for its own requirements and with an appreciable surplus for export, and do this on a sustained yield basis for many times its present population. All agricultural efforts of the present should be concentrated on such lands. Improvements in crops and agricultural techniques to raise production to a much higher level are possible and have been demonstrated already in limited areas.

On the other hand, clearing of new land for agriculture should not be allowed to progress into areas of rough topography or low fertility, as such terrain can not support a stable, high level agriculture. This leads to undesirable future socio-economic problems and also, in many cases, through alteration of stream flow and erosion, jeopardizes the permanent high-quality agricultural lands below with the threat of floods or scarcity of water for irrigation. Furthermore, the original area, before despoilation, may have had a much higher potential value for other uses such as timber production or recreation, over and above the values of stream regulation and protection for wild life.

Specific examples of what should be stimulated and what should be avoided can easily be found in Panamá. Some of the rice plantations along the railroad between David and Concepción in Chiriquí Province with their high degree of mechanization demonstrate very well that man can produce surplus food effectively by using the right methods in the right areas. Again in the same general region, the banana plantations near Armuelles demonstrate the tremendous productivity possible by good land use and the employment of advanced techniques. The Chinese vegetable growers near the Canal Zone demonstrate clearly what can be accomplished with intensive management and careful maintenance of the soils.

On the opposite side of the scales, numerous examples of misdirected effort could be cited which are detrimental or represent economic losses to the nation. The felling and burning of magnificent stands of previous woods on the hills in Darién Province for the production of one or two crops of grains is a good example of waste of natural resources and economic loss to the nation.

In the Cerro Azul area, only a few miles by car from Panamá City, the hills rise up into the cool air of the subtropical belt. Here there are picturesque forests and magnificent views of the surrounding lowland to and beyond Panamá City a swell as of the coast and the Pacific Ocean. This whole area of the subtropics so close to the capital city has an inestimable value for recreation and rest as it offers the possibility to get away rapidly from the heat and noise of the city. The entire section should be zoned for future vacation home sites and public parks. On the contrary with the arrival of roads in the locality there is actually a growing attempt to develop the area agriculturally with coffee plantations and grazing which at the same time will detract from the recreational value of the area. This is a clear case of the lack of long term planning and unwise land use, as in addition to the fact of the high value for recreation the vegetation indicates that the

area is not suitable for long term, profitable agriculture.

Considerable survey work and study of the area of low-fertility soils in Coclé and southwestern Panamá Provinces which offer little possibility for economic improvement have been carried on recently. It would appear that in light of the limited number of soil technicians available that efforts should be concentrated first on the areas of potentially highly productive soils such as those to the south and southwest of Concepción in Chiriquí Province or on some at the other lowland areas mentioned previously.

The fertile lowlands with their inherent richness and adaptability to mechanization offer not only high productivity per man and hence potential high levels of living for the agriculturist, but also the best possibilities for advancement in crop improvements and agricultural techniques. Such agricultural zones can develop and support good road systems, advanced educational systems, good housing and high health standards. Through their high productivity per unit area and per man, such agricultural lands can play a very important role in reducing pressure on submarginal lands and in freeing a percentage of the labor force of the nation for development of industrialization. Development of wet land rice cultivation should be considered, because of its high productivity per unit area.

Similarly to crop production a grazing industry which is based on the use of extensive areas of poor land with run-of-the-mill stock and cheap labor can provide excellent profits for a few families of large land-holders, but contributes very little towards the raising of the general level of living or to the prosperity of a nation. Sound development must be based on intensive land use of suitable areas with concerted efforts to improve the herds and the pastures. Examples do exist in Panamá of such progressive farms showing that such developments are possible and profitable. Such intensification must be stepped up to prevent further expansion of the industry into areas which are not suitable and are truly submarginal for grazing. Even though as pointed out previously, such lands may produce profits for one family this is brought about at the cost of a low, unsatisfactory level of living for several families of laborers, a status not conducive to general prosperity and strengthening of the nation.

The present assignment of fertile flat lands to either cultivation or grazing is still largely based on the personal preferences of the owner. Further technical advances in these fields should lead to a more economically desirable assignment of lands to their optimum use. There seems to be a healthy adjustment taking place now in this respect as, for example, may be observed to the east of Panamá City towards Chepo where flat, easily mechanized portions of previously grazed lands are being segregated and utilized for crop production.

Aside from economic and market conditions which have their particular importance on crop selection, the distribution and acreage available of high quality soils should be considered in the light of the life zones or formations. As an example of this the subtropical moist forest represents the ideal climate for *Coffea arabica* L. but the plant will produce well also on recent volcanic soils of the Subtropical Wet Forest. In Panamá, the acreage available for expanding coffee culture appears quite limited. As a matter of fact, coffee is being spread in Panamá both beyond its climatic limits and into soils which will not be highly productive. The inversion of capital in a crop away from optimum conditions tends to handicap general progress. In the first place such capital is diverted away from more productive investments and second, such landholders are prone to oppose the raises in wage and living levels of agricultural laborers which would automatically bankrupt their submarginal operations.

Since cacao is an excellent crop for the tropical moist forest and large areas of rich alluvial soils are available within that life

zone for the expansion of this crop, investments in cacao plantations, as opposed to coffee appear much more desirable for Panamá. Also, as recent investigations have demonstrated, cacao, offers many opportunities for technical improvement of present cultivation practices.

In general, until much more investigation has been carried out on management of tropical soils and agricultural techniques, it is safer to follow the indications of the natural vegetation and avoid attempts to produce crops where more than normal problems will arise. The tropical moist forest is essentially a tree climate and best results are to be expected with crops such as cacao, bananas, plantains, rubber, oil palms, abaca and the like. In the tropical dry forest formation, field cropping of grains and maintenance of grasslands for pasture is much simpler. Within this life zone in Panamá are to be found the best conditions for producing upland rice, corn, cotton, sugar-cane, ajonjoli, beef cattle and tropical fruits such as mangos, avocados, nisperos, caimitos, etc. Where flat, fertile lands can be irrigated, production possibilities are very favorable.

The mountain formations, with the exception of level or gently sloping valley lands, should be permanently reserved in forest. In the very near future, Panamá should close up such mountainous areas to agricultural expansion and assign the reservations as national forests. Subsequently, these reserves can be studied and divided up into the classifications of production forests, national parks, wilderness areas, etc. according to their highest use. The reservation at this time would be politically easy but if reservation is postponed until many people have moved into the areas as colonists, many additional problems will be confronted.

As pointed out previously, such areas can not support permanent agricultural settlements with a satisfactory level of living, so that their closure to agriculture in that respect is on the best interests of the nation. Furthermore, the maintenance of such lands in forest guarantees protection from disastrous floods and assures adequate supplies of water for irrigation and hydroelectric power development, thus insuring stability for the highly productive agricultural zones below. Subsequently, they become increasingly more important for recreational use and timber production.

Darién

The province of Darién is considered sufficiently distinct and so lightly affected by man to date as to warrant separate treatment in this report. As may be noted on the map the greater part of the lowland areas fall in the tropical moist forest formation, but the annual rainfall averages are so close to the approximately 80 inch line of division with the dry forest that we have mapped a large portion as a distinct transition zone. Around the Ensenada de Garachiné and in the upper reaches of the Rios Sabana and Chucunaque is found dry forest of a transitional nature also, even though on areas of sandy soil and coral limestone outcroppings in the former district, the vegetation appears at first glance to indicate still lower rainfall. Along the Pacific coast to the south and towards the Colombian border and San Blas, rainfall increases to give rise to typical moist forest and with increasing elevations considerable areas of the subtropical wet forest and small areas of lower montane wet forest are encountered.

The present population of Darién is scattered in a few towns or settlements on the coast, the estuaries or the rivers with agricultural development on the fertile alluvial lands close to water transport. Bananas and plantains appear to be the main commercial crops of the agriculturists, the latter often following bananas which are more susceptible to disease. The main industry of the region is that of logging, with logs of precious woods cut for export to Central Panamá and outside and with some milling of lumber of various species carried on within the province. Because of the relatively light influence of

man to date in the province, Darién offers excellent possibilities for careful planning of the future utilization of its resources.

The five most significant facts to be considered in the planning of Darién, are as follows: (1) the great differential between low and high tides, (2) the rich alluvial or gently sloping lands between mean high tide level and hilly country, (3) the tide or swamp forests over extensive areas with homogenous stands of one or a few species, (4) the enormous potential timber value in the dry land forests where so many precious woods are to be found and, (5), the extensive system of natural navigable waterways running through this wealth of resources. Sea-going steamers can enter the estuary of the Rio Sabana and up the Rio Tuira to Chepigana. In addition, the strong tides extend their influence far up the rivers for the benefit of smaller embarcations.

Agricultural development of the region on any large scale is potentially both promising and precarious. The most promising areas at the moment are those alluvial or very gently sloping lands back from the waterways towards the hills where the flood waters from a combination of high tides and full rivers in the rainy season do not reach or significantly affect the terrain. These areas are very little used at present because they are away from current river transportation.

Between these areas and mean high tide level occurs a much more extensive zone of level terrain and fertile alluvial soils which offer the greatest promise for agriculture if effective flood control measures can be established. Parts of this zone are now utilized for agriculture but when occasional abnormally high water occurs, the people with their pigs and chickens must retire to their houses on stilts and await the lowering of the flood waters. Such a system of agriculture restricts the number of crops which can be grown and perhaps invites disaster which might come in some excessively rainy period.

Today, with powerful earth-moving machinery available, there is no doubt but what engineers could lay out and erect a system of dikes and drainage which could convert extensive areas into highly productive farm land. An additional advantage of such diked lands over ordinary agricultural areas is that flood waters may be tapped at any planned time to deposit an enriching layer of alluvium over a given portion.

Since such scientific agriculture in the Darién most probably await some future time when population expansion and world food needs are more pressing, first attention should be given to existing problems, but, at any rate, land use should keep in mind and not destroy the potentialities for such planned future use. In this consideration the hilly areas and the wetter upsteam zones of Darién should be reserved in the near future to avoid agricultural use. This is desirable because a very low percentage offers promise for level agriculture and any widespread clearing would result in more rapid runoff and higher flood levels and thus destroy the potential value of the alluvial plains.

The broken area up the Tuira River, and perhaps several other sections of the Darién Province might very well be set aside as national parks. The beautiful stretches of the Tuira, with rocky ledges along the river and the attractive natural forest would someday offer great attractions for tourists, if the natural conditions can be maintained.

For this same reason, the development of a grazing industry in Darién is not considered desirable. Although a very few existing ranches have given good results and obviously, the climate and soils are satisfactory, any considerable extension of grazing would automatically lead to a greater and greater use of fire and the destruction of the hill forests. The potential value of the alluvial plains for mixed agriculture is so great that neither shifting cultivation in the uplands nor grazing on a large scale should be allowed to jeopardize their future use.

Of all Panamá, Darién Province does offer exceptionally favorable opportunities for industrialization of forest products. The internal system of waterways, the pure stands of

Fig. 5. - Deforestation of marginal land along the rivers in Darién is a common sight.

Fig. 6. - The headwaters of the rivers in Darién have magnificent scenery. Some day they will constitute a true source of wealth to stimulate tourism and for hunting and fishing as well as for recreation aside from their protective value... if by that time they are still in their natural condition.

tide-land and the presence of very appreciable quantities of high quality woods in the dry land forests are here combined in a manner which is unique or rarely found in the Americas.

The present exploitation of the forests in the area is a rather wasteful use of the forest resources and adds little to the development of the province. In the mangrove forest trees are felled for their bark alone with the whole trunk being left to rot on the soil. In the mixed hardwood forests, some of the logging operations take out only one or two species, such as mahogany and Spanish cedar, and actually harvest only the straight logs or portion of the tree. No thought is given to the future of the forests.

Here, is a clear case where the combination of forest resources presents the possibility of an integrated industrialization for real permanent benefit to the province and the Republic of Panamá. Panamanian capital could well combine with foreign capital and technical industrialization knowledge for mutual benefit. At the present time three types of industrialization processes appear to offer excellent opportunities.

The first of these is a veneer or plywood plant, as Darién has large quantities of several precious woods suitable for face veneers and also abundant supplies of less valuable woods for core stock. One plywood factory near Panamá City has operated with timber supplies from Darién Province, although it is difficult to understand any advantages, if they exist, for the actual location of the plant in relation to supplies.

Another type of industry would be feasible here or would combine well with the plywood and sawmilling industry. This is that based on the Novapan process developed in Switzerland. In that process, lumber is artificially built up from chipped wood on the same principal as that of plywood, in that an inferior wood is used for the major part of the board and faced on both surfaces with wood that is attractively grained or colored. Since all of the wood in this process is reduced to chips or shavings, it is possible to obtain much of the raw material for the facing at least from what would normally be left in the woods as short lengths or large limbs or discarded as waste at a sawmill or plywood plant. The processed wood or chips are then mixed with glue and pressed into boards or products of similar form. This process has the advantage of permitting the addition of chemicals to prevent such deteriorating factors as termite damage and because it can utilize so much material is to be recommended highly for industrial integration.

A third type of board fabrication reduces the wood of one or several hardwooded species down to its fibers, much as in the pulp making process. These are then spread out into thick sheets subjected to heavy pressure and emerge as large sheets of a thick, strong fiber board. The fibracel plant operating at Ciudad Valles, near Tampico, Mexico is a sample of this type of plant. Such a plant might feasibly use such woods as mangrove or alcornoque which occur in pure stands over large areas close to the waterways. Any use of the red mangrove wood which could be combined with the extraction of the bark for tannin would be highly desirable.

Once industrialization of the wood resources of the Darién were under way, the developed system of transportation would allow for harvesting and shipping specialty woods. Also, it is very likely that uses could be found for some of the abundant species such as cuipo which are now considered worthless. The development of economic production of pulp and cellulose from tropical woods, production of sugar from wood cellulose, and conversion of wood sugars to proteins in yeast cultures are some of the industrialization processes not far in the offing and these factories will tend to move in where other industrial plants have led the way.

Other possibilities of more direct use suggest themselves also. Short lengths, large limbs and partly rotted logs of mahogany and other species could supply a plant making up

furniture parts to be exported in unassembled form from the province.

During the survey, we were impressed also by the tremendous numbers of the local palm called "guagara." This is a hard-fibered palm with a tall straight trunk probably averaging between 6 and 8 inches in diameter. It would appear worthwhile to carry on tests with this palm as a possible upright minetimber for export, because if suitable for such a use, the economics of extractions to shipping points seem satisfactory.

Summary

In brief, Panamá possesses an abundance of renewable natural resources, which if utilized correctly on a rational basis can develop enormous wealth and a general high level of living for even a greatly expanded population. However, to bring about this correct utilization will require careful planning and education of the general population in wise resources use. Government leaders and local capitalists must direct their efforts and money into those projects and areas which can be developed on a permanent basis with possibilities for profit not only for the land-owner and capitalist, but also which offer an opportunity to raise the living levels of all who work on the projects.

One of the most pressing needs of the country for such planned development, are local technicians in many land-use fields to carry on research, to serve as extension agents, or teachers, or to fill field posts as technicians or administrators. There is still time to do this while many of the natural resources are still more or less intact but procrastination in development of wise use of the resources while population numbers grow by leaps and bounds will make the task much more difficult or even impossible after a few more years.

Since the forest areas and resources are so extensive and the economic possibilities for industrial forestry development offer such promise, one of the immediate tasks to be undertaken by the government of Panamá should be that of training forestry technicians and the establishment of an effective national forest service. Such a service should undertake at a very early date the reservation of national forests and parks in extensive areas of the mountainous and hilly regions and also undertake studies in the forests which offer the best possibilities for industrial development. The forestry industries, which require heavy investments for their establishment are interested in long-term operations. Therefore, they are highly desirable, since they strive to maintain the forests on a permanently productive basis and work towards a better level of living of the inhabitants.

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